Vol. L. No. 4

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THE LARGEST COLD STORAGE PLANT in England has been built at the Southampton docks by the London & Southwestern Ry., and the building is of concrete-steel construction throughout. It has a capacity of 2,500,000 cu. ft. of which 1,730,000 cu. ft. are available for storage. It is designed to hold 6,000 sides of beef on the ground floor, 155,000 frozen carcases of sheep in the basement and second floor, and large quantities of fruit and vegetables, eggs, etc. The goods delivered by vessels are conveyed by link-belt conveyors to the top or distributing floor and there automatically deposited. From this floor the goods are sent to the various departments by 1½-ton electric elevators running at 100 ft. per minute. On the bottom floor are traveling tables, by which 56 carcases of beef per minute can be handled. A special power plant supplies current for driving 18 ventilating and circulating fans and 1,500 lamps, 37 motors aggregating 130 HP. being required. The storage chambers are maintained at 14°F., and there are four De LaVergne refrigerating machines.

THE NEW CHICAGO TERMINAL STATION was opened to train service on July 12, the office building which forms the headhouse having been in use since May. This station is owned and occupied jointly by the Chicago, Rock Island & Pacific Ry., and the Lake Shore & Michigan Southern Ry., and is used also by the New York, Chicago & St. Louis Ry. The station fronts on Van Buren St., occupying the narrow block between La Salle and Sherman Sts., while the great trainshed extends south to Harrison St. The ticket, baggage and other offices are on the first floor, at the street level. The waiting-room and tracks are on the second floor, with a bridge connecting with the station of the elevated loop. The headhouse is 212×156 ft., 12 stories high, with railway offices on the upper ten floors. The trainshed is 578 ft. long, the roof being carried by pin-connected trusses of 207 ft. span, having curved top and bottom chords. The architects were Frost & Granger, and the consulting engineers for the steel construction were E. C. & R. M. Shankland. The general contract was let to the Wm. Grace Construction Co.; while the steel work was built by the American Bridge Co. and erected by Oscar Daniels. All the above are Chicago firms.

A NEW TRANS-SIBERIAN RAILWAY SCHEDULE has been issued. Hereafter express trains will leave Moscow four times—instead of three times per week. The trip from Moscow to Dalny, 5,368 miles, can now be made in 13 days by fast trains and in 17 days by the slow trains. The distance to Port Arthur is 5,388 miles. The express trains only run from Moscow to Irkutsk. Thence to Manchuria station, 4,197 miles from Moscow, post and passenger trains, and from Manchuria station to Dalny, express and post trains. The new tariff, including sleepers, calls for the following rates, first and second class: Moscow to Irkutsk, $61.23 and $38.90; Moscow to Vladivostock, $119.46 and $74.90; Moscow to Port Arthur, $134.05 and $84.50. These rates include the crossing of Lake Baikal by steamer. A special train of three passenger cars and one baggage car can be procured for the Far East, at 2 rubles per verst, or $1.03 for 0.663 mile, on the Russian railways, and 50% additional on the Chinese roads. At these rates this special train from Moscow to Port Arthur would cost nearly $8,200.

THE LUCIN CUT-OFF across Great Salt Lake is said to be nearing completion, and it is stated trains will be running across within six months. The two most troublesome sink holes have been filled with rock and earth. Seven steam shovels and 3,000 men are at work filling in the temporary trestles. For fifteen miles of the line permanent trestles will be used instead of filling.

METAL CROSS-TIES ON BRIDGES on the line of railway from Ismid to Angora, in Asia Minor, are now being replaced by oak ties. The all-metal construction proved so rigid that the pounding of the traffic affected the connections of the bridge members. The metal ties, of an inverted V-shape, were riveted directly to short bearing plates, which in turn were riveted to the tops of the stringers; on curves the bearing plate under the outer end of the tie was heightened to form a riveted chair giving the proper amount of superelevation. After some ten years of service many of the ties have partially failed where the rail rests upon them. The substitution of wooden ties gives an easy-riding track and is expected to greatly reduce the annual repair cost. It may be noted that the natives in that region have gradually learned to respect the railway so that stealing of the wooden ties (wood is very scarce in this region) is a much smaller source of loss than it would have been during the first years of the railway.

A HIGHWAY DRAWBRIDGE of 200 ft. span, with two shore spans of 80 ft., will be erected across the mouth of the harbor at Sydney, New South Wales, Australia. The draw span has deck trusses with curved bottom chords, and its turntable rests upon a live ring of 66 cast-steel rollers running upon a cast-iron track 35 ft. in diameter. The width of the bridge is 50 ft. between the hand rails. It is operated by electricity, the operation being controlled from a cabin spanning the roadway at the middle of the bridge. The shore spans have parallel-chord deck trusses. The three spans have been built by Andrew Handyside & Co., of Derby, England.

THE NEW HIGH LEVEL BRIDGE OVER THE TYNE, at Newcastle, England, is the largest bridge undertaking let in that country since the Forth bridge was completed. The estimated cost is $2,350,000. The new bridge will be used for railway traffic only, and besides affording greater care and speed in working the railway lines concentrated at Newcastle, it will save at least $100,000 per annum in locomotive power. The three main piers will be founded on steel caissons, 43 ft. long by 35 ft. wide, sunk 69 ft below high-water mark. The main bridge will be a steel riveted lattice truss, 1,100 ft. long, consisting of three river spans each 300 ft. long and two side spans of 240 ft. Each main span will include five lattice girders 320 ft. long, 27 ft. deep and 4½ ft. wide; and each main girder will weigh over 300 tons. The four lines of rails on this bridge will be 110 ft. above high water, with 83 ft headway under the girders. The work is in charge of Mr. Charles A. Harrison, Chief Engineer of the Northeastern Ry., and the Cleveland Bridge & Engineering Co., of Darlington, has the contract for the piers and superstructure.

TWENTY INTERLOCKING PLANTS at railway grade crossings in Texas have been ordered built before June 30, 1904, by the Railroad Commission of Texas. These plants, together with those herebefore ordered and approved, make a total of 62 interlocking plants that have been completed or have been ordered to be constructed by the Commission, all of which must be completed before June 30, 1904. Of the above plants 14 have been completed and their operation authorized by the Commission, and 19 more are now under actual construction. Of these in operation eleven are mechanical lever machines and three are electric machines constructed by the Taylor Signal Co. Of those under construction seven are to be mechanical machines and twelve are to be electric. At the present time Texas has upwards of 200 main line grade crossings of railroads. The control of the question of protecting grade crossings of railroads in Texas was conferred on the Railroad Commission by an act of the Legislature passed in 1901.

THE BALANCING OF DRIVING WHEELS of locomotives is avoided in some new eight-wheel engines built by the London & Southwestern Ry., England, to the designs of Mr. Dugold Drummond, Locomotive Superintendent. These engines, which are for fast passenger service, have inside cylinders and crank axles. The axles are of the built-up type patented by Mr. Drummond, and the crank webs extend beyond the axle, being enlarged so as to form balance weights. All the revolving weights and part of the reciprocating weights are balanced in the axle. Other features of these engines are Mr. Drummond's system of transverse tubes through the firebox, and tenders carried on two four-wheel trucks instead of on three rigid axles, as in the ordinary English practice.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Baltimore & Ohio Ry. near Lorain, O., on July 14. A freight train, which failed to take a siding as ordered, was run into by an opposing freight and wrecked. Two men of the train crews were killed.

THE EFFECT OF THE PASSAIC VALLEY TRUNK sewer is now being investigated by a commission representing the State of New York. A special commission acting in behalf of the State of New Jersey has already reported favorably on the project, as noted in our issues of July 9 and 16. The New York commission has just organized, with Dr. Daniel Lewis, State Health Commissioner, as Chairman, and Mr. Louis L. Tribus, M. Am. Soc. C. E., Commissioner of Public Works, Richmond Borough, New York City, as Secretary. Other members of the commission are Prof. O. H. Dandreth, M. Am. Soc. C. E., Schenectady, N. Y.; Mr. Geo. A. Soper, Assoc. M. Am. Soc. C. E., New York City, and Myron S. Falk.

CHANGES IN THE ST. LOUIS SEDIMENTATION reservoirs are proposed for immediate execution. The six basins, each some 400×700 ft., were operated until recently on the continuous flow plan. In our issue of June 20, 1902, there appeared a brief note (p. 519) from Mr. Edw. Flad, M. Am. Soc. C. E., then water commissioner of St. Louis, describing some experiments in the method of operating the basins which it was proposed to make. Three of the basins were to be continued in service on the continuous plan, each acting separately, and three others were to be operated in series. It is now reported that the whole six basins will be operated in series, the water flowing from one to another over long weirs. Mr. B. C. Adkins is now water commissioner of St. Louis, and Mr. E. E. Wall is first assistant engineer of waterworks extensions.

THE NERNST LAMP seems to be working its way into a wide range of use. Information received at various times from the Nernst Lamp Co. indicates that a number of towns have adopted the lamp in place of incandescent lamps for street lighting, either tentatively or permanently. Its utilization for interior illumination is best represented by the lighting of the Farmers' Bank Bldg., Pittsburg, Pa., a 24-story building lighted throughout with Nernst lamps. The equipment comprises 20 six-glower lamps, about 450 c. p. each; 20 two-glower (150 c. p.), and 2,250 single-glower lamps of 55 to 88 watts each (25 and 50 c. p.). From the information at hand it seems that for ordinary interior lighting single-glower lamps are the rule, while for larger interior units, and for the lighting of halls or train sheds, or for street lighting, three-glower and six-glower lamps are usually furnished.

THE PRODUCTION OF PIG IRON by grades in the United States is given in the last report of the American Iron & Steel Association for the years 1901 and 1902. The figures given are as follows:

Grades.	Gross Tons. 1901.	Gross Tons. 1902.
Bessemer and low phosphorus pig iron	9,596,703	10,393,168
Basic pig iron made with mineral fuel	1,448,850	2,038,590
Forge pig iron	639,454	833,093
Foundry pig iron	3,548,718	3,851,276
Malleable Bessemer pig iron	256,532	311,458
White and mottled and miscellaneous grades	87,964	172,085
Spiegeleisen	231,822	168,408
Ferromanganese	59,639	44,573
Direct castings	8,582	8,656
Totals	15,878,354	17,821,307

In 1902 the production of low phosphorus pig iron, which is chiefly used by manufacturers of acid open-hearth steel, was for the first time definitely ascertained. It amounted to 164,246 gross tons, and was made by four states—namely, New York, New Jersey, Pennsylvania and Tennessee.

BRICKLAYING IN WINTER is a regular thing in Stockholm, Sweden, according to a report by the British consul there, Mr. S. MacGregor. No special precautions are taken when the temperature is not below 14° F., but in colder weather the sand and water are heated and the mortar is mixed in a room where the temperature is kept above freezing. Plastering or cement work, however, is never carried on in freezing weather unless inclosed and heated. Pressed brick and stonework are usually not placed in freezing weather, or if in small amounts, as in belt courses or ornaments, they are heated before placing.

THE PLANT OF THE HUDSON PORTLAND CEMENT CO., AT HUDSON, N. Y.

One of the most important additions to the growing list of American Portland cement plants using limestone and shale or clay as raw materials is now being built at Hudson, N. Y. The first mill of this plant, with a capacity of 2,000 barrels of cement per day, will be placed in operation early this summer, and it will be followed immediately by a sister mill of the same capacity, and later by others, until the ultimate capacity of the plant, namely, six 2,000-barrel mills, is reached. When completed the plant will be one of the largest ever built in America for the utilization of limestone and shale for Portland cement manufacture by the rotary kiln dry process.

The site of the Hudson Portland Cement Co.'s works is on the east bank of the Hudson River, directly on the water front of the city of Hudson, its storehouse platforms forming in fact the wharf front of the city at this point. On the opposite or shore side of the plant are the main tracks and yards of the New York Central & Hudson River R. R. The plant thus has shipping facilities by deep water craft to New York and the Atlantic Ocean, by canal boat to the north and west, and by railway to all parts of the country, and, by a particularly direct route, to the northern New England states. In general arrangement the plant is about as follows: Along the wharf front there are a series of cement storehouses set end to end with intervals between. Back of these storehouses is a line of switch track from the New York Central & Hudson River R. R. Then comes the several mills, rectangular in plan, and set end-on to the switch track and side by side. It will be understood that this arrangement refers to the plant as it will be ultimately completed; at present only one mill and one storehouse, with their accessories, are being built. The compactness of its arrangement is one of the noticeable features of the plant, and this compactness is particularly evident in the arrangement of each unit, or mill, as will be perceived from the accompanying plans.

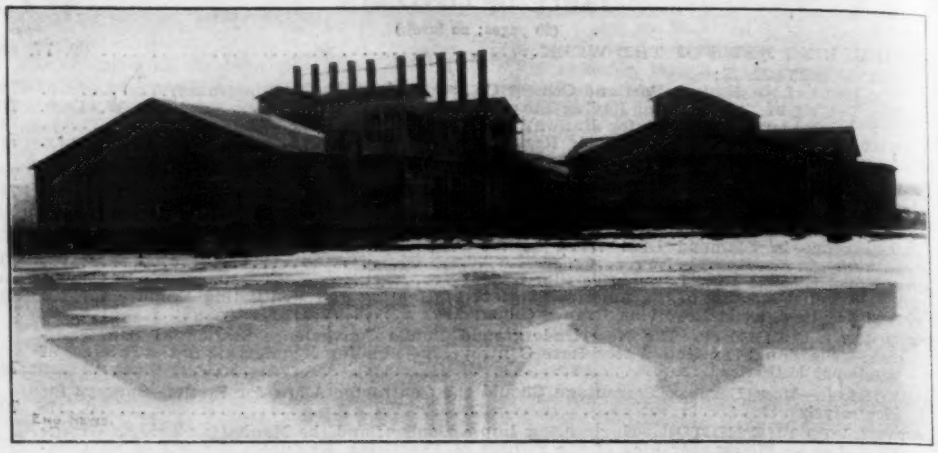

FIG. 1. GENERAL VIEW OF CEMENT MILL AND POWER HOUSE OF HUDSON PORTLAND CEMENT CO., AT HUDSON, N. Y.

SOURCE AND CHARACTER OF RAW MATERIALS.—The source of the raw materials which are to be used in the Hudson cement works is the shale, clay and limestone deposits which form the ridge rising from the river bank, and extending east from the city of Hudson. This ridge is known as Becraft Mountain, and the Becraft limestone deposits have long been known as among the most important deposits of this rock in New York state. Two types of limestone are found here, namely, the Becraft, or Scutella, limestone, and the blue Pentamerous rock. Small quarries have been opened in the Pentamerous rock and it has been employed to some extent for road metal, but the most abundant rock is the so-called Becraft limestone. This material forms the summit of the ridge and has long been used for building stone and for iron furnace flux, first in the old Hudson Iron Works and later in the furnaces at Troy and Poughkeepsie, N. Y. It is a coarsely crystalline, fossiliferous rock, running high in carbonate, and of a uniform character. The following is a typical analysis of the rock:

Silica (SiO_2)	.90%
Alumina and Iron ($Al_2O_3Fe_2O_3$)	1.01%
Carbonate of Lime ($CaCO_3$)	97.02%
Magnesia (MgO)	trace

This limestone deposit is all contained in the 1,100-acre tract of land purchased by the cement company, and the same tract also comprises extensive deposits of clay and shale. The following are typical analyses of these latter materials:

	Clay.	Shale.
Silica (SiO_2)	48.56%	62.[illegible]%
Alumina (Al_2O_3)	24.07%	20.[illegible]%
Iron (Fe_2O_3)	8.51%	7.[illegible]%
Lime (CaO)	3.69%	[illegible]%
Magnesia (MgO)	3.48%	1.49%
Moisture, etc.	11.23%	8.03%

The stone and clay deposits are connected by standard gage railway with the cement plant, the railway cars entering the plant on a trestle and discharging onto the crusher room floor beneath. The movement of the loaded trains from quarries to mill is down grade.

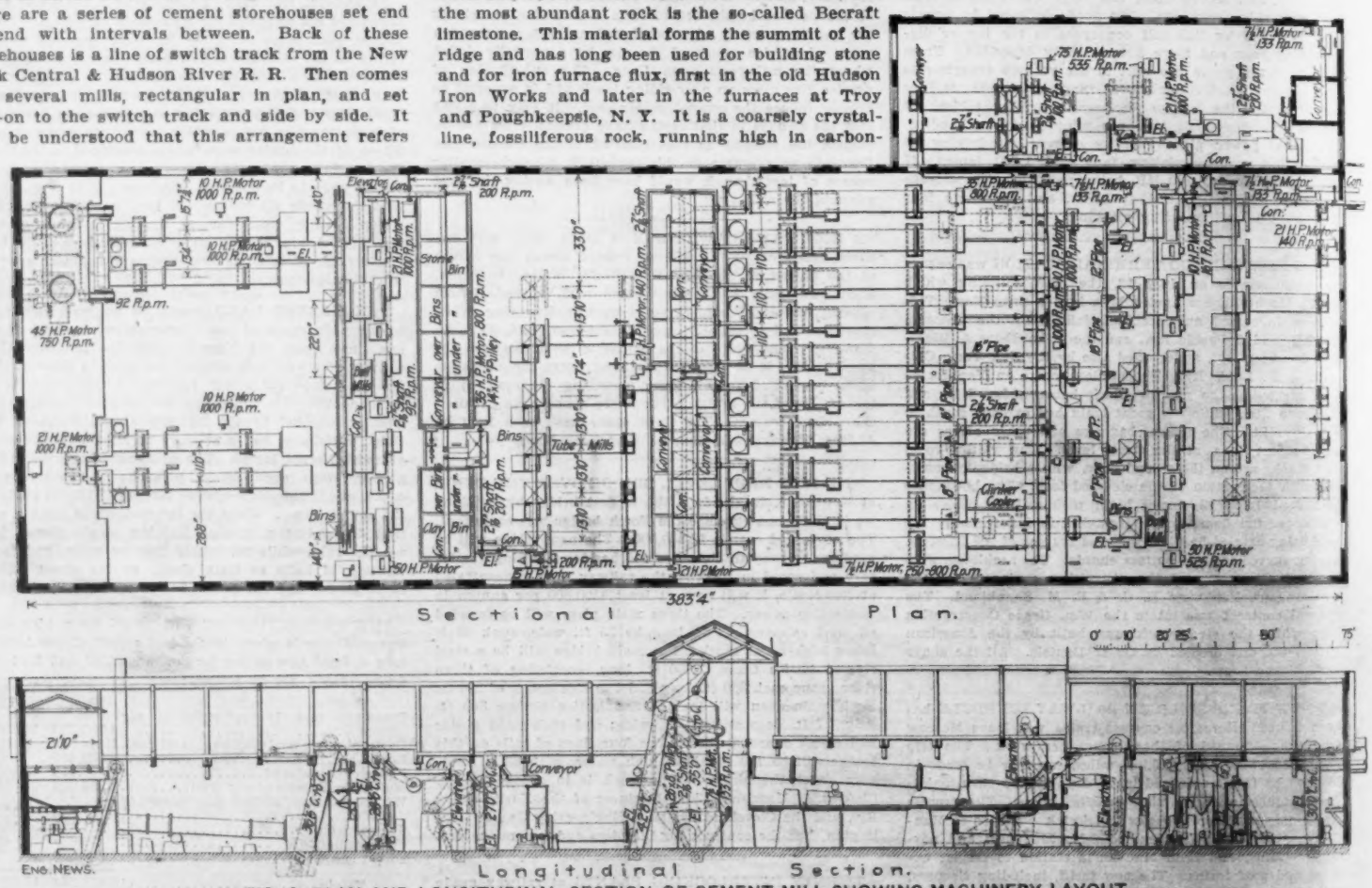

FIG. 2. PLAN AND LONGITUDINAL SECTION OF CEMENT MILL SHOWING MACHINERY LAYOUT.

CEMENT MILL.—As noted above, the several cement mills which will compose the plant are substantially identical in construction and equipment, so that a description of the single mill now approaching completion will give a fairly good understanding of the plant as a whole. Fig. 1 is a general view of this mill from the river. At the left is the mill proper, with the wharf, which is to carry the cement storage building, shown in front. The lean-to wing contains the plant for pulverizing the coal used in the rotary kilns. At the right is the power house. Fig. 2 shows a plan and longitudinal section of the mill building with all its machinery in place. This building is 383 ft. 4 ins. long and 116 ft. wide inside, exclusive of

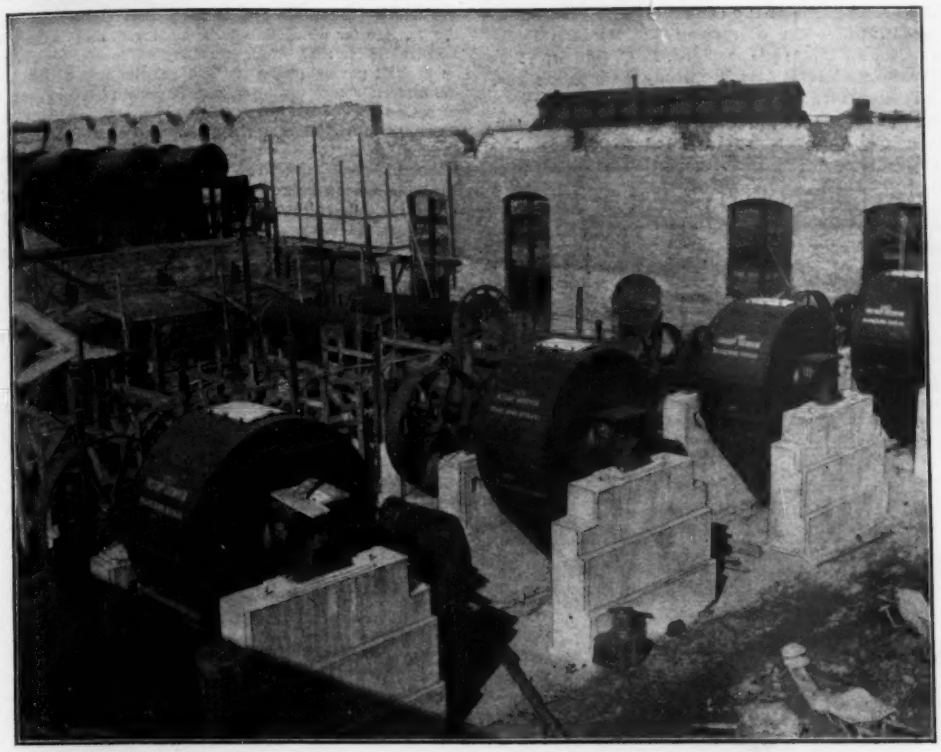

FIG. 3. VIEW SHOWING BALL AND TUBE MILLS FOR RAW MATERIALS DURING ERECTION.

wing. It is built with brick walls, and the roof is carried by timber trusses resting on the side walls and a center row of cast-iron columns. The ventilators and other superstructure are all of timber construction. This timber construction was adopted only because deliveries of steel could not be secured in time for the work.

Turning now to the machinery equipment of the main building and its lay-out, reference will be had to the plan and section of Fig. 2. The machinery equipment of the building may be divided into: (1) The machinery for preparing the raw materials for calcination; (2) the kilns and coolers or calcining apparatus; (3) the cement grinding machinery; (4) the coal grinding machinery; and (5) the system of conveyors and elevators which handles the various materials from one set of machinery to another in the course of their transmutation from quarry rock to finished Portland cement. All of this machinery is operated by electric motors, some of the machines having individual motors and others being driven in group by a central motor, and all is shown in place by the drawings of Fig. 2. Briefly itemized, the machinery for preparing the raw materials for calcination comprises crushers for disintegrating the quarry rock, driers for removing the moisture from the crushed rock, ball mills for coarse grinding and tube mills for fine grinding, with the necessary storage bins interspersed to store the material in its different stages of reduction. The calcining apparatus comprises the rotary kilns and the rotary coolers for cooling the clinker. The cement grinding machinery comprises ball mills for coarse grinding and tube mills for fine grinding.

Following the course of the material step by step, it will be seen that the loaded cars from the quarry come into the mill at the east end at an elevation of 12 ft. above the crusher room floor, which is itself elevated 13½ ft. above the main mill floor, and that they dump through the track onto the crusher room floor. Flush with this floor are the tops of three rotary crushers, two for crushing limestone and one for crushing shale. The two limestone crushers are run by a 45-HP. electric motor, and the shale crusher by a 22-HP. electric motor. From the crushers the stone is delivered, shale and limestone separately, into four rotary driers, each of which is operated by a 5-HP. electric motor. From the driers the stone passes separately to the ball mills for the first grinding. These ball mills are of the Krupp type and there are five of them, each operated by a 50-HP. electric motor. These ball mills are clearly shown by the view, Fig. 2, taken during construction. From the ball mills the shale powder is delivered to a set of two bins, and the limestone powder to a set of five bins. These bins are so constructed as to discharge automatically into a double elevator, whence the materials are discharged into a double hopper over a tandem automatic weighing machine, which weighs out the proper proportion of each material. The two products are then mixed thoroughly by being conveyed together by elevator E and conveyors 9½ and 9 to the steel bins feeding the tube mills. There are six of these tube mills and they are driven in groups by a 75-HP. electric motor. Two of them are shown erected in the view, Fig. 3.

The tube mill discharges feed onto a screw conveyor 10, thence to the elevator E E, and thence to screw conveyor 11, which discharges into two groups of stock bins. Screw conveyors 13 running underneath these bins take the material right and left to the elevator F, which feeds the right and left screw conveyors 12 that discharge into the kiln feed bins. There are ten of these bins and each one feeds one rotary kiln. The kilns are 60 ft. long and 6 ft. in diameter, and each is driven by a 7½-HP. electric motor. Fig. 4 is a view of the underside of the kilns showing the rolls on which they run. The immense size of these modern cement burners is excellently indicated by this illustration. From the kilns the clinker is run into rotary coolers. There are five of these, one for each pair of kilns. In these coolers the clinker is coled by a current of air which is blown in at the forward ends and passes out of the rear ends into the trunk mains whence the air pipes to the kilns branch off. The coal is thus blown into the kilns by heated air. From each cooler the clinker drops into a clinker pit and from these pits the elevators G hoist it to the bins of the five Krupp ball mills.

From the tube mills the underground screw conveyor 14 and the elevator H take the powder to the double hopper where the final adjustment of proportions is made if necessary, and thence the conveyor 15, the elevator H H and the conveyor 16 take the powder to the feed bins of the seven tube mills, for final grinding. The discharge from the tube mills is taken by the conveyor 16½ to conveyor 26, which leads to the storage bins.

The course of the coal through the drier and grinders in the coal-grinding room and thence by conveyor 24, elevator L, and conveyor 26 to the powdered coal bins for the kilns can be readily traced from the drawings of Fig. 2, and need not be explained further here.

In a general way there is comparatively little to be noted regarding the cement mill which is not evident from the drawings. The compact and orderly arrangement of the several sets of machines in transverse rows and the entirely automatic handling of all material from the stone crushers to the cement storage house are facts to be noted. The respective machines are of standard makes, and while they are the best of their make, they are in no respect of special or novel character. The regeneration of the heat from the cement clinker to heat the air blast carrying the coal to the kilns is worth attention, as perhaps not being common, but on the whole it is the compactness of

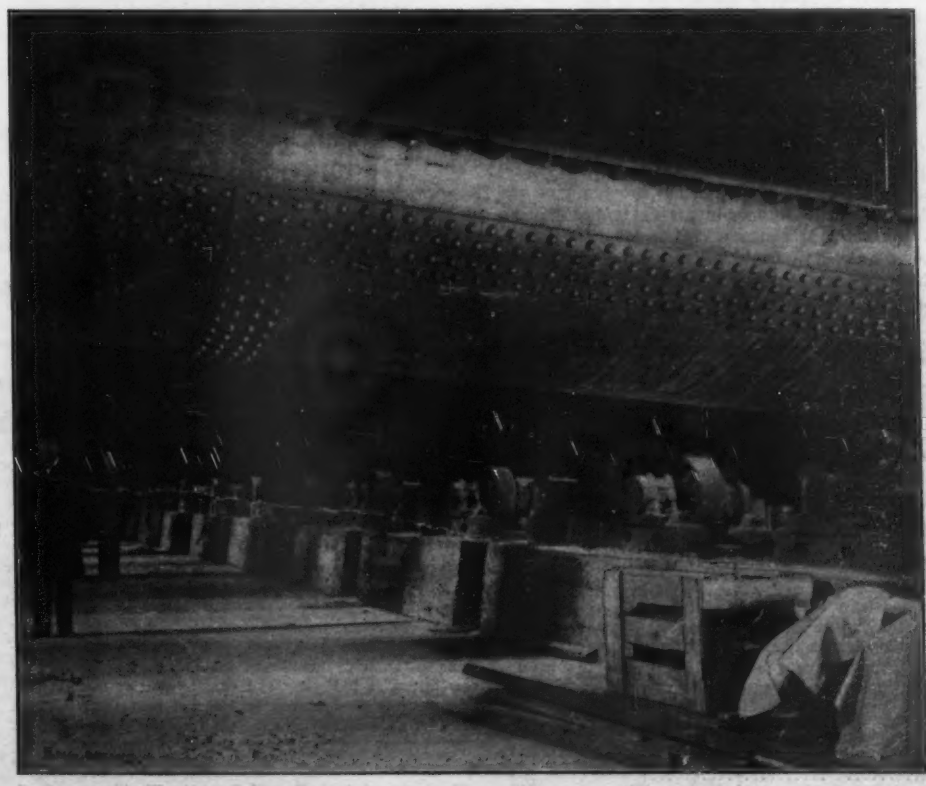

FIG. 4. VIEW UNDERNEATH ROTARY KILNS SHOWING CARRYING ROLLS.

the arrangement of mill equipment that is the special merit of the plant.

STOCK HOUSE.—The stock house is a structure 410 ft. long and 105 ft. wide. Fig. 5 is a foundation plan and Fig. 6 is a plan of the bins. These are divided into three groups of 20 bins each. Transverse and longitudinal sections through the bins are shown by Fig. 7, and these explain clearly their form, and general dimensions. The stock-house foundations consist, as shown by Fig. 5, of a series of concrete walls founded on piles. The bins themselves are of wood, their walls being laid up solid of 2 × 10-in. and 2 × 8-in. pine plank laid flat and spiked together. The view, Fig. 8, taken during construction, gives a good idea of the construction employed. The total capacity of the 60 bins is 200,000 barrels of ground cement.

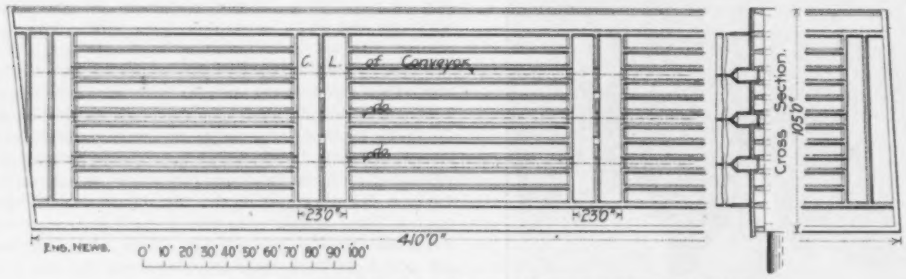

FIG. 5. FOUNDATION PLAN OF CEMENT STOCK HOUSE.

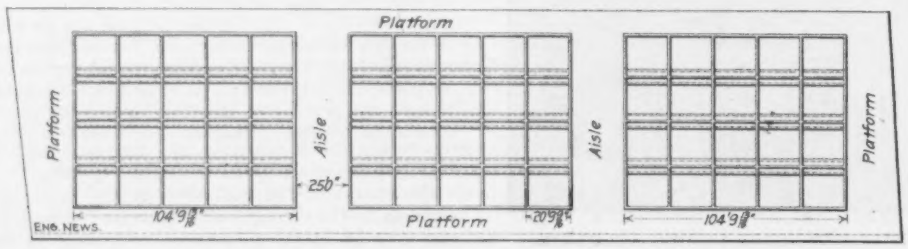

FIG. 6. PLAN OF BINS IN CEMENT STOCK HOUSE.

Cement is conveyed to the stock house from the mill by means of conveyor 26, which discharges into the boot of elevator O, Fig. 7. This elevator discharges into the transverse screw conveyor 27, which spouts onto two belt conveyors running lengthwise of the building over the bins. From these belts the cement can be deflected into any one of the 60 bins. The drawings of Fig. 7 show all of these conveyors quite clearly and also the construction of the several parts of the structure not explained by Figs. 5 and 6.

POWER HOUSE.—The power house, as already noted, is a separate structure built to one side of the cement mill, as shown by Fig. 1. It calls for very little mention except to note that all equipment is of high quality. The boiler room is equipped with Heine safety boilers of an aggregate capacity of 2,500 HP., with economizers and B. F. Sturtevant induced draft system. The engine room is at present equipped with three cross-compound, heavy-duty Corliss engines, built by the Murray Iron Works, of Burlington, Ia. These engines have a nominal horse power each of 900 HP., and are direct-connected with the generator shaft. The generators have a capacity of 500 KW. each.

FINISHED PRODUCT.—No cement has yet been made by the plant described, but the company has for some time burned its raw materials in a small shaft kiln and made cement for experimental purposes. Analyses of this cement and tensile tests of briquettes have been furnished us as follows:

Silica (SiO_2)	21.60
Alumina (Al_2O_3)	9.27
Iron (Fe_2O_3)	3.80
Lime (CaO)	61.78
Magnesia (MgO)	1.27
Sulphuric Acid (SO_3)	1.53

The following is the result of tensile strength in pounds per square inch of 100 briquettes made from the above materials:

Age.	Neat Cement.	3 to 1 Mortar.
48 hours	540	...
7 days	676	226
28 days	778	294
90 days	869	349

The brand name of the cement will be "Hudson."

OFFICERS.—The officers of the Hudson Portland Cement Co. are: President, L. C. Smith; Vice-President, F. B. Scott; Secretary and Treasurer, B. Lyman Smith; and General Manager E. Bravender. The plant was planned and designed by Mr. Bravender, and we are indebted to him for the material from which this description has been prepared.

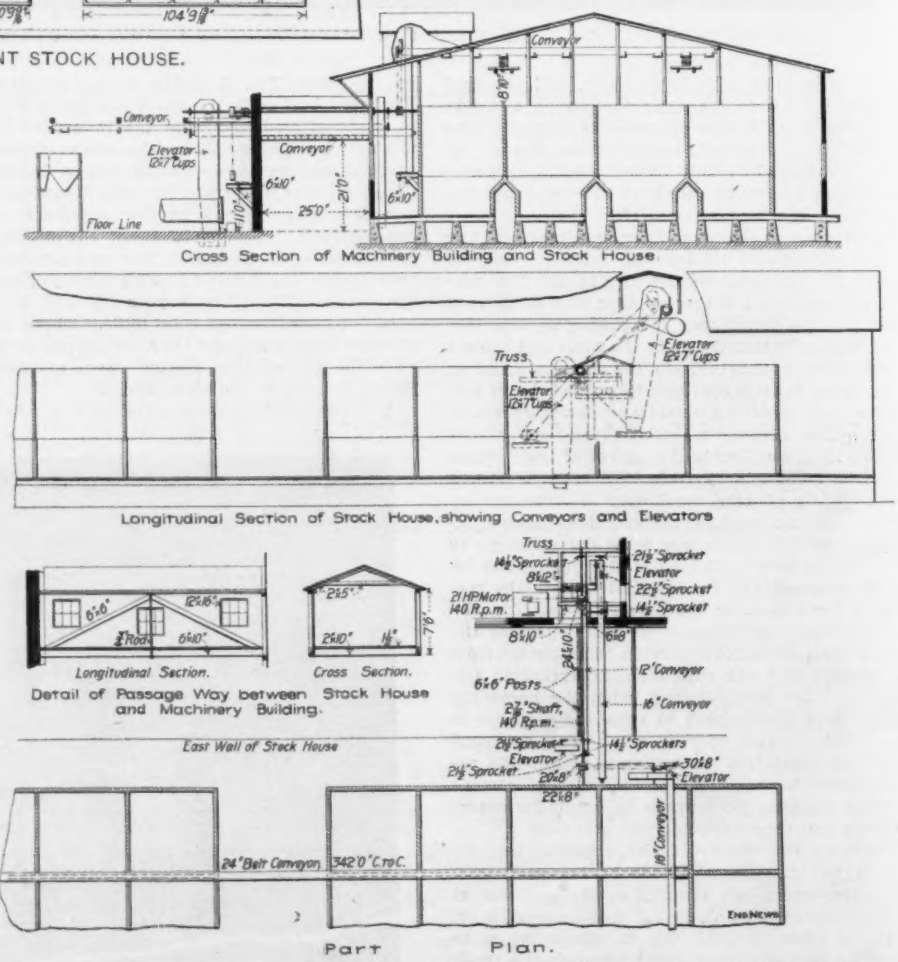

FIG. 7. PLAN AND SECTIONS OF STOCK HOUSE SHOWING CONVEYING MACHINERY.

THE TESTING OF BITUMENS FOR PAVING PURPOSES.*

By A. W. Dow.†

It is surprising when one considers the large quantity of bitumen used each year, and its numerous applications in the many industries, that more attention has not been given to the study and examination of the physical properties of this interesting class of bodies. Why is it not just as essential to examine into the properties that a bitumen should possess, to meet the requirements of the purpose for which it is to be employed, as to examine a hydraulic cement? There are many million dollars spent on asphalt paving each year, and yet the examination of the materials entering into these pavements is neglected, excepting in one or two instances, and the majority of these are entirely devoid of any real value, as the examinations are not based on a careful study of the requirements and conditions. The only explanation I can offer for this lack of interest or attention to the testing of these materials is that it does not fall within the scope of any of the professions.

The testing of bitumens is devoid of any true chemical methods, and it is evident from their complex composition and great variation in chemical composition, that it will be a long time before chemistry will play an important part in the determination of their properties. It is not to be wondered at, either, that engineers do not consider the testing of bitumens as being within the scope of their profession, as the physical properties and laws governing bituminous construction are so different from those relating to the materials usually met with in engineering work.

At the last annual meeting of the International Association for Testing Materials, the formation of a committee was authorized, known as No. 34 (for the settlement of a uniform definition and nomenclature of bitumen). Dr. Lunge of Zurich was appointed chairman, Mr. C. Richardson and myself accepting the American membership. In a circular letter addressed to the members of the committee, Dr. Lunge proposed that the committee not only devote its attention to the nomenclature, but to arriving at uniform methods of testing bitumens. The establishing of uniform methods in any subject is of course very desirable, but it is a question whether the time is ripe for such an undertaking in the field of bitumens, as there has been so little work done in this subject, and by so few persons. The only tests that I believe sufficiently established to warrant any unification in the methods of procedure, are those for the determination of the total bitumen, and the amount of bitumen soluble in naphtha.

But I do not present this paper with the hopes of establishing any uniform methods at the present time, but more for the purpose of bringing before the society for discussion the fundamental laws governing asphalt construction, and some physical tests which I have adopted for the examination of asphalt materials for determining their suitability for use in paving.

The theory of asphalt construction is but little under-

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vised. This is because the proper physical laws are not applied in reasoning on this subject, which is not surprising when we consider that the other cementing materials in general use in engineering work are solids, and involve the laws governing the cohesion and adhesion of solids for each other, while in the case of asphalt construction we have entirely different principles involved—those governing the cohesion of liquids and adhesion of liquids for solids, for asphalt paving cements are in every sense of the word, liquids. It is because this fact is unknown, disregarded or thoughtlessly overlooked by analysts and engineers, that the majority of literature on the technical examination of asphalts is so lacking in value.

To better illustrate this, a description of how one class of asphalt pavement is constructed, and a discussion of its properties will not be amiss. What is known as a sheet asphalt pavement is one made of a mixture of sand with an asphaltic cement. As the asphaltic cement used is excessively viscous at ordinary temperature, this mixing is of necessity done while the materials are heated to a degree sufficiently high to render the cement so fluid as to readily coat the sand. This mixture of sand and asphaltic cement is spread on the street and compressed into a continuous sheet by means of rolling. These operations are performed while the mixture is heated, as it is more easily handled and compressed while in this state.

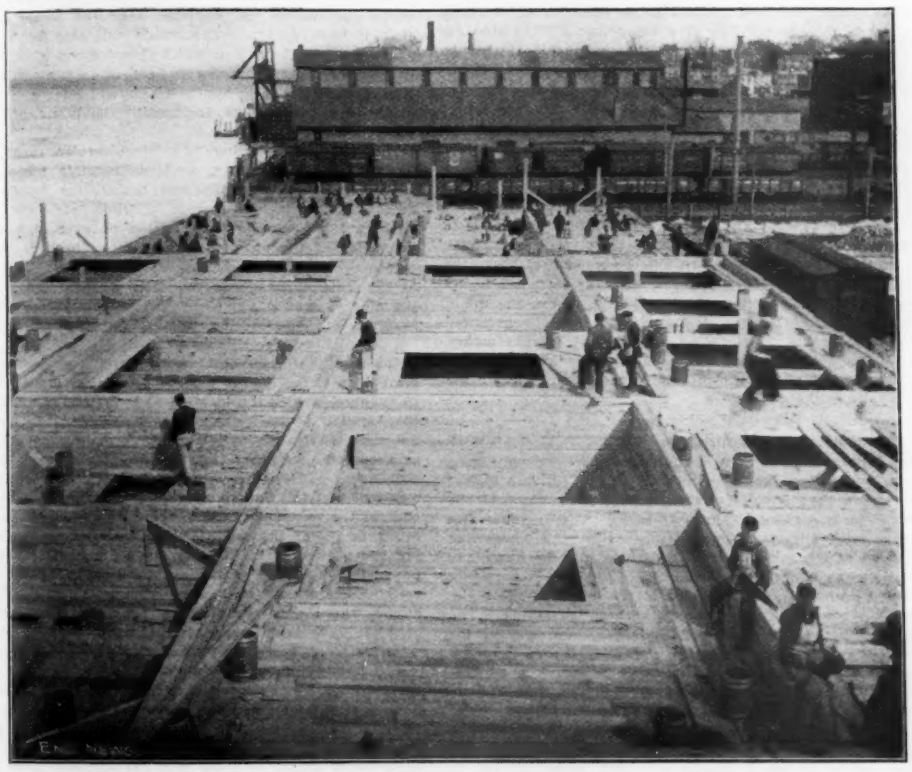


FIG. 8. VIEW SHOWING STOCK BINS UNDER CONSTRUCTION.

This pavement must have the following properties:

(1) It must be composed of such a material that it will not crush or be ground away by traffic at any climatic temperature. To accomplish this, the asphaltic cement which surrounds the sand grains must be pliable and elastic at all temperatures, for, if it were solid and ridged, the mixture would soon grind away.

(2) As an asphalt pavement is laid in one continuous sheet, it is necessary that the cement used be so ductile, even at the lowest temperature obtained, that the pavement may contract without cracking.

(3) It is also necessary that the pavement be so firm at the maximum climatic temperature obtained, as to withstand the passage of traffic without either being cut into so badly as to be objectionable, or shoved to the side of the street.

(4) The paving mixture must be as dense as is possible, so as to preclude the entrance of water into its voids, for if water enters and freezes, the mixture is expanded and becomes spongy, and, if the asphaltic cement is not sufficiently pliable, it will wear away by abrasion.

(5) The pavement must not contain any material that is acted on by water, for even though it were possible to construct a paving mixture so dense as to preclude the entrance of water into it, yet the mixture being pliable under the passage of traffic, water will work into it if it contains any material that is soluble.

(6) The pavement must not contain an asphaltic cement that will age so rapidly as to cause the pavement to lose its pliability before a reasonable period of time.

A pavement possessing all these qualities will be durable under all normal conditions.

Although the use of different sands in a pavement will change its physical properties somewhat, yet they are principally dependant on the physical properties of the asphaltic cement with which it is constructed. A pavement, to possess the properties above enumerated, must contain an asphaltic cement which will be so ductile at the minimum temperature obtained in the climate in which it is laid, as to permit a contraction of the pavement without cracking. At the same time the asphaltic cement must not be rendered so fluid by the maximum climatic temperature that it will produce a pavement objectionably soft.

The asphaltic cement must possess the property of flowing at all temperatures to which it will be subjected. It is upon this property that the adhesiveness of an asphaltic cement depends. Comparing two asphaltic cements of the same degree of consistency, the one that approaches more closely to being a true liquid possesses the greater adhesiveness. This is true not alone from observation, but is self-evident when we examine into why a bituminous cement is adhesive. The property of adhering is not chemical, but purely mechanical, and the more fluid the cement is, the more completely and perfectly will it flow every cavity of the surface in which it is in contact, thus producing a more perfect bond or adhesion.

It must not be inferred from the above remarks that the cement which approaches most closely to the true liquid, and for this reason is most adhesive, is the most desirable for asphalt construction. This is not the case, for cements, as they approach the condition of being perfect liquids, are found to be more susceptible to changes in temperature that is more brittle in the cold and more softened by heat.

Besides these physical properties, the asphaltic cement must be able to withstand the heating to which it will be subjected in the process of manufacture into pavement, without having its physical properties materially changed, and must not be rapidly hardened or so changed by age as to lose its ductility and pliability in an unreasonable short period of time. For the determination of the above properties, I have devised the following tests:

DUCTILITY.—The ductility of an asphaltic cement is determined by ascertaining the distance that a prism of this cement can be drawn out before breaking. This test I make at 20° F. The test is also made at 77°, the one that is the more ductile is the more perfect fluid, and hence the most cementicious.

SOFTNESS AT HIGH TEMPERATURE.—The softness of an asphaltic cement at high temperature I determine by ascertaining its consistency at 32, 77, 100 and 115° F. The rate of softening of an asphaltic cement is thus determined, and an idea can be arrived at as to whether it would be too soft for use at the maximum climatic temperature.

FLUIDITY.—As to how true a fluid an asphaltic cement is, I determine as given above.

HEAT TEST.—To ascertain whether the asphaltic cement will be injured by the heating which it must undergo during the process of manufacture into the pavement. This is determined by submitting a quantity of asphaltic cement of known consistency by penetrating at 77° to a temperature of 300° F. for eight hours. During this heating the asphaltic cement is stirred from time to time to break up any skin which may form on its surface, thus protecting it from evaporation and oxidation. After this heating the cement is allowed to cool, and its consistency by penetration is again taken at 77°, the difference in penetration being the amount of hardening resulting from the prolonged heating.

CHANGE DUE TO AGING.—All bitumens undergo a more or less rapid change with aging that appears to be due to two or possibly more causes. Two distinct changes manifest themselves. One is the surface hardening, which is likely due to oxidation, and possibly to the volatilization of light oils. It begins at the surface and gradually extends into the bitumen. The other is a hardening of the entire mass, evidently due to condensation of molecules. Both these changes take place in all bitumens, but one or the other may predominate. The former is much the less objectionable, as it makes but slow progress into the mass.

The best method for determining the aging of the asphaltic cement, although it is somewhat slow, is as follows: The asphaltic cement is placed in a sample tin, and its consistency by penetration determined at 77° F. This sample is then put away in some place protected from the dust, but without a cover, so as to have free access of the air. At the end of two weeks or a month the consistency of the sample is again tested at the same temperature, when it is again put away. This testing every few weeks is kept up until the sample is appreciably hardened. A slanting cut is then made into it with a sharp, thin knife, laying over the upper piece, thus exposing a gradual descent from the surface into the interior of the cement. Penetrations are now taken down the side of this cut, beginning at the surface. In this way the increase in hardness of the surface and the interior over its original consistency is determined; also, the hardening of the surface over the interior and the depth that the surface hardening has entered the sample.

Another method which I have lately employed, and which is somewhat more rapid, is by taking an asphaltic cement of known consistency by penetration at 77°, and spreading 50 grams of it on a piece of plate glass 9 × 9 ins. square. The plate thus coated is placed away in a dust-proof drawer. At the end of two weeks or a month the coating of cement is scraped from the plate by a steel straight edge, and molded into a suitable receptacle at the lowest temperature possible. The consistency by penetration is again taken, and the increase in hardness of the asphaltic cement indicates its rapidity of aging. This method, of course, does not differentiate between the two hardenings.

As all asphaltic cements are not of the same degree of purity, it is necessary for comparison that the tests for their physical properties be made on a basis of the pure bitumen. For this reason it is necessary to ascertain the relation existing in the various tests made on the asphaltic cement, and the pure bitumen it contains. After such a ratio has once been established, test can be made on the asphaltic cement, and allowance made for the impurities other than bitumen. Due allowance can then be made in comparing the results of physical determinations on cements of different purities.

CHEMICAL TESTS; CARBON DISULPHIDE, SOLUBLE.—As the cementing material in a paving mixture or asphaltic cement is the pure bitumen it contains, an extraction with carbon disulphide is made to ascertain the amount of this cementing material. It is also necessary to determine the purity of an asphaltic cement to aid in drawing conclusions from the physical tests.

For the extraction of bitumen some advise the use of other solvents, such as chloroform and turpentine, because they extract more from bitumenous materials than does carbon disulphide. The use of these more powerful solvents is unnecessary, as, at its best, this test is only comparative, for there is strong evidence to show that even carbon disulphide, in the case of some asphaltic cements, dissolves more bitumen than really acts as a cementing material, and in the cases where all the bitumen appears to be cementitious, the chloroform and turpentine dissolve little, if any more, than does the carbon disulphide. This being true, I cannot see any reason for adopting a still more powerful solvent. Carbon disulphide also has the advantage that it is more readily obtained pure, is less hydroscopic and cheaper than chloroform and turpentine.

NAPHTHA SOLUBLE.—The test for the amount of bitumen soluble and insoluble in naphtha, or as it is better known, the test for the petrolene and asphaltene, is usually made by extracting the asphalt or asphaltic material with petrolic ether. The bitumen that dissolves in the solvent is called petrolene, and that portion which is insoluble but which dissolves in carbon disulphide, is spoken of as asphaltene.

I do not believe there has ever been a test that has caused more confusion than this one, by its being mis-

interpreted and its value overestimated. It is of no value at all, as is sometimes claimed, in determining whether or not an asphalt would make a good pavement. This has been demonstrated by practical observation, which is also verified by the results obtained by Prof. H. W. Harper of the University of Texas, in his report contained in Bulletin No. 3, University of Texas Mineral Survey. The amount of bitumen soluble in naphtha is of no value excepting as indicating, within broad limits, the degree of hardness of an asphalt. The test is of advantage because it requires no apparatus other than is found in every chemical laboratory, and if standard methods could be adopted, it would be of value as indicating in a limited degree the consistency of the asphalt.

ACTION OF WATER ON PAVEMENTS.—The action of water on asphalt pavements has, in the past, received little or no consideration from engineers. This question, I believe, is a very important one, and asphalt should be examined to determine whether or not it is attacked by water or moist air. There are many failures resulting from this action that have been blamed to other causes in the past, and a more thorough study of this subject is much to be desired.

A simple method which I have adopted to ascertain the rapidity of the action of water, is by coating a piece of glass with the asphalt paving cement, and partly immersing this coated glass in distilled water. The coating is examined at intervals, and the time noted when the first discoloration or action is noticed on the surface of the sample.

Another method which I sometimes use is by molding two 1-in. cubes of the paving mixture under a fixed pressure. This mixture is made with a standard sand, and the same amount of bitumen used each time. One cube is immersed in water while the other is kept in air. These cubes are examined at the end of a month or two, and any increase in the volumn or softening of the one in water over the one kept in air, is noted.

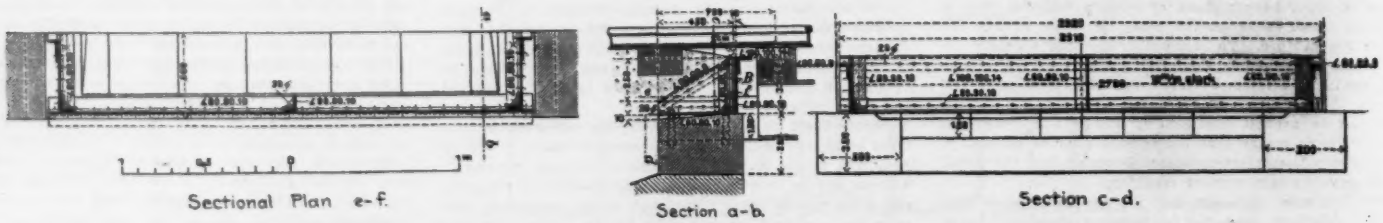
It is to be hoped that this paper will bring out some discussions on the properties of bitumens, or that it will inspire some to take an interest in an investigation of the physical properties of these much neglected materials.

A SPECIAL ABUTMENT DETAIL FOR RAILWAY BRIDGES.

The cut shown herewith, reproduced from the "Centralblatt der Bauverwaltung," shows a special construction for railway bridge abutments which has been used for some years in the state of Hanover. It was designed to give a more satisfactory support for the track at the end of the approach. Ordinarily, the last tie of the approach track is laid either on the top of the abutment masonry, or immediately behind the wall of masonry behind the bridge-seat, which wall in this case is carried up to the base of rail. If the former method of support is used, the rigidity of the track at the end tie is apt to produce a shock in fast running, and to damage the abutment masonry. On the other hand, when the last tie is bedded in the ballast close behind the masonry, it is difficult to properly tamp the tie and a soft spot in the track may result from failure on the part of the maintenance gang to keep the tie solidly bedded.

Both these evils are avoided by the construction shown. The masonry is kept low enough so that the ballast can extend over its top and have a sufficient depth below the tie to give the latter proper bedding. A steel-plate curb at the outer edge of the masonry holds the ballast in place. With this arrangement the end tie may be placed at the normal tie-spacing distance from the last tie on the bridge, and yet have sufficient space on its river side to allow tamping.

The steel curb plate is about 12 ins. high; it consists of a ⅝-in. plate stiffened with angles and braced back by two triangular gussets also stiffened with angles. The main plate as well as the braces are anchored to the masonry by ¾-in. stone bolts. The weight of the entire curb is about 500 lbs. Its cost is to a great extent made up for by the saving due to the less height of the abutment masonry.



BALLAST CURB FOR RAILWAY BRIDGE ABUTMENTS.

SURVEYS FOR ELECTROLYSIS AND THEIR RESULTS.*

By D. H. Maury,† M. Am. Soc. C. E.

No problem which at present confronts those charged with the preservation of underground pipe systems is of more vital importance than the protection of these pipe systems from electrolysis. There are now before the courts at least five important electrolysis suits. In three of these suits, the taking of testimony is as yet unfinished; the other two are now awaiting decision. A large number of cities and corporations whose pipes have been seriously injured are anxiously awaiting the decisions in these cases before beginning similar actions. Under these circumstances, it is important that every pipe owner should know as much as possible of the progress of the damage, and of the actual conditions as they from time to time exist, in order to be thoroughly prepared for action when the time comes.

PURPOSE OF SURVEYS.

Naturally, the best method of getting this information is to secure the services of a competent and reliable expert to investigate and report; but a great deal may be accomplished by any intelligent water-works superintendent having only a rudimentary knowledge of electricity. It is hoped that this paper may give some suggestions that may be useful to such superintendents, whose duty it is to see that the pipes under their care are not destroyed by currents wrongfully allowed to stray upon them.

Let us assume that the objects of the survey are to trace, in a general way, the flow of current from rails to the pipes, along the pipes, and from the pipes back towards the rails or other return conductors, to prove the origin of, and responsibility for, this current; and to get some idea, necessarily approximate only, of the amount of damage caused by it. A map should first be prepared showing clearly the location and size of all the mains, and the location of all street railway tracks and power stations, and of the return conductors leading back from the rails to the generators.

INSTRUMENTS REQUIRED.

The instruments required for the electrical field work are few in number. There should be a Weston voltmeter, with two scales, the lower one reading to not less than 1 nor more than 5 volts at the limit of the scale, and the upper scale reading 10 times as high. There should also be a millivoltmeter having two scales, the lower one reading to a maximum of 10 millivolts, and the upper one 10 times as high, or to 100 millivolts. Both instruments should preferably have the zero in the center of the scale, so that reversals may be read without switching. The millivoltmeter may be converted into an ammeter by inserting between the terminals a shunt of proper resistance; but as a general rule, it will be found more convenient to make determinations of current flow by the "drop of potential" method, to be referred to later.

In digging for pits in pipes, the blade of the ordinary pocket knife will sometimes close upon, and cut, the fingers, while the small handle will soon make blisters in the palm of the hand. A much better tool for this purpose can be constructed by having a blacksmith forge and temper a short, stout blade, 1½ ins. long, from a piece of an old file, and then set this blade firmly in a wooden file-handle. A hammer and cold chisel will be needed for knocking the hard scale off the pipes, and a wire brush is sometimes handy, especially for cleaning wrought-iron pipes. There should also, of course, be the necessary lamp cord for leads for the instruments; and, if the ammeter is used, suitable heavier cables will be needed.

MEASUREMENTS OF DIFFERENCE OF POTENTIAL.

The first step in the survey will usually be the reading of the difference of potential between hydrants and rails at various parts of the system. Two men besides the observer make a good working party for this purpose; and with a light wagon or surrey to transport men and instruments, from 25 to 40 such readings can be taken in a day. It is advisable to continue the observations at each point for several minutes, so as to note the extreme variations when cars are near by as well as when they are not in the vicinity. These readings should at once be recorded in the notebook, and transferred to the map at the close of the day, so that they may serve as a guide in laying out the work for the next day.

The measurements of difference of potential between hydrants and rail should be taken more with a view to getting a general idea of the normally positive and negative areas, so as to locate the best places for afterwards exposing the mains for inspection, than for any other purpose. They will, of course, indicate the territory in which the deepest pittings will be caused to mains and service pipes by the current which is permanently leaving the pipes to return to the rails or other conductors leading back to the power station. Such injury goes on more rapidly in the neighborhood of the power station, or where the return conductors are connected to the rails; but it is by no means confined to this territory. For instance, it will be usually found that at the extreme dead ends of car tracks, the mains will be strongly negative to rails when cars are using current near by, and slightly positive to the rails at all other times. This means that in these outlying districts current is leaving the pipes, and pitting them just as in the districts near the power station, though less rapidly. The mains will also be pitted at every point in the city at which they happen to be positive to any other nearby piping system, or to the earth, or to anything adjacent; in short, which will offer any sort of conducting path from the mains back to the power station.

The voltmeter readings also incidentally throw some light upon other points, such as possible underground connections between rails and mains, the condition of track bonding in the various districts, etc., but unless supported by actual measurements of current flow, and inspection of the pipes themselves, they form insufficient evidence on which to base a suit, and their importance in this respect has been too often exaggerated. Unless the pipe system is unusually large, from 75 to 100 such readings will generally be sufficient for practical purposes.

EXCAVATIONS.

The results of these observations having all been clearly platted on the map, the next step will be to study them in connection with the location and size of the mains, and the location of the rails and return feeders, in order to get some idea as to the best places to make excavations, to expose mains for inspection and for measurement of current flow. These excavations should not be confined to any one district, but should be so distributed that each one may give results which shall as nearly as possible fairly represent the conditions in the territory surrounding the particular excavation. Some excavations should be made where the mains are normally positive to the rails; some where the mains are normally negative, and others where they are alternately positive and negative, at what have been erroneously termed "neutral points." As a matter of fact, there are no "neutral points," for the varying conditions of load in a street railway system cause the point at which there may be for the moment no difference of potential between mains and rails, to keep continually moving in and out, its travel frequently extending over a mile, and sometimes much more. One or more excavations should be made near the extreme outer limits of the car lines and mains, preferably where both the car lines and the main on the same street are "dead ends." At such points the current in the mains can be clearly and conclusively shown to come from the operation of passing cars, as every movement of the needle can be seen to be directly coincident with the corresponding movement of the controller-handle on the car.

One or more excavations should be made near the power station, or return feeder taps leading thereto, to prove that the current in the mains returns to the power station; and it is well to carry on a series of readings at one of these points as well as at one of those at the outer end of the car track, from, say, 11 o'clock at night until the cars begin to run again next morning; an observer, with compared watch, being detailed to note the exact time when the last cars go into the barn, and when the first cars leave it in the morning. In this manner the flow of current can be absolutely proven to be caused by the operation of cars from the generator at the power station. If there be two or more street railway systems operated from separate power stations, it will not be pos-

*A paper read before the American Water-Works Association, Detroit, Mich., June, 1903.

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sible to identify the current in the center of the system as being produced by any particular generator; but it is perfectly easy to prove that some current from each generator does go on to the pipes at the outer end of its trolley system, and that a corresponding amount of current does leave the pipes for that generator when the pipes are positive to the rails near the power station.

If the street railway companies attempt to protect themselves with the specious plea that in order to collect damages from one of them, when all are causing it, it is necessary to exactly apportion the amount of damage for which each is responsible, their defense will only react upon themselves; for it will serve to emphasize the fact that the only possible relief from the evil is for all of them to cease to cause the damage, which can only be accomplished by the complete removal of all of their currents from the rails and earth.

MEASUREMENT OF CURRENT.

The "drop of potential" method of measuring currents is based on the well-known Ohm's law, $C = \frac{E}{R}$; or

Current = Electromotive Force divided by Resistance.

By this simple formula, if we know the electrical resistance of the length of a conductor between the two terminals of the millivoltmeter, and we read the difference of potential, or of electromotive force, we can calculate the current.

For convenience in measuring the current flowing in cast-iron and wrought-iron pipes, the writer has prepared the following tables:

Current-Flow in Cast-Iron Pipe with One Millivolt Drop.
(From tests showing average resistance per pound per foot = .00144 ohm.)

Inside diam. of pipe in ins.	Approx. w't. per ft. without bell.		Distance between points of contact on pipe. 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
			Current on pipe per millivolt drop.									
4	20	.....	13.9	6.9	4.6	3.5	2.8	2.3	2.0	1.7	1.5	1.4
6	30	.....	20.8	10.4	6.9	5.2	4.2	3.5	3.0	2.6	2.3	2.1
8	39	.....	27.1	13.5	9.0	6.8	5.4	4.5	3.9	3.4	3.0	2.7
10	58	.....	40.3	20.1	13.4	10.1	8.1	6.7	5.8	5.0	4.5	4.0
12	84	.....	58.3	29.1	19.4	14.6	12.0	9.7	8.3	7.3	6.5	5.8
16	120	.....	83.3	42.0	28.0	21.0	17.0	14.0	12.0	10.0	9.3	8.3
20	180	.....	125.0	63.0	42.0	31.0	25.0	21.0	18.0	16.0	14.0	12.5
24	220	.....	153.0	76.0	51.0	38.0	31.0	25.5	22.0	19.0	17.0	15.0
30	310	.....	216.0	108.0	72.0	54.0	43.0	36.0	31.0	27.0	24.0	22.0
36	440	.....	306.0	153.0	102.0	76.0	61.0	51.0	44.0	38.0	34.0	32.0
42	560	.....	389.0	195.0	130.0	97.0	78.0	65.0	56.0	49.0	43.0	39.0
48	720	.....	500.0	250.0	167.0	125.0	100.0	83.0	71.0	62.0	56.0	50.0
60	900	.....	624.0	312.0	208.0	156.0	125.0	104.0	89.0	78.0	69.0	62.0

Current-Flow in Wrought-iron Pipe with One Millivolt Drop.
(From tests showing average resistance per pound per foot = .000181 ohm.)

Inside diam. of pipe in ins.	Approx. weight of pipe per ft.		Distance between points of contact on pipe. 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
			Current on pipe per millivolt drop.									
¼	2.68	.....	14.8	7.41	4.94	3.71	2.96	2.47	2.12	1.85	1.65	1.48
½	3.61	.....	20.0	10.0	6.65	4.99	3.99	3.33	2.85	2.50	2.22	2.00
¾	5.74	.....	31.7	15.9	10.6	7.94	6.35	5.29	4.53	3.97	3.53	3.17
2	7.54	.....	41.7	20.9	13.9	10.4	8.34	6.95	5.93	5.21	4.63	4.17
3	9.00	.....	49.8	24.9	16.6	12.4	9.95	8.30	7.11	6.22	5.53	4.98
3½	10.66	.....	59.0	29.5	19.7	14.7	11,8	9.83	8.42	7.37	6.55	5.90
4	12.49	.....	69.1	34.5	23.0	17.3	13.8	11.5	9.87	8.63	7.67	6.91
4½	14.50	.....	80.2	40.1	26.7	20.0	16.0	13.4	11.5	10.0	8.91	8.02
5	18.76	.....	104.0	59.6	34.6	25.9	20.7	17.3	14.8	13.0	11.5	10.4
6	23.27	.....	129.0	64.3	42.9	32.1	25.7	21.4	18.4	16.1	14.3	12.9
7	28.18	.....	156.0	77.9	51.9	39.0	31.2	26.0	22.3	19.5	17.3	15.6
8	33.70	.....	186.0	93.2	62.1	46.6	37.3	31.1	26.6	23.3	20.7	18.6
9	40.00	.....	221.0	111.0	73.7	55.3	44.2	36.9	31.6	27.7	24.6	22.1
10	45.02	.....	249.0	125.0	83.0	62.2	49.8	41.5	35.6	31.1	27.7	24.9
11	49.00	.....	271.0	135.0	90.3	67.7	54.2	45.2	38.7	33.9	30.1	27.1
12	54.00	.....	290.0	149.0	99.5	74.7	59.7	49.8	42.7	37.3	33.2	29.9
13	58.00	.....	321.0	160.0	107.0	80.2	64.1	53.5	45.8	40.1	35.6	32.1
14	62.00	.....	343.0	171.0	114.0	85.7	68.6	57.1	49.0	42.9	38.1	34.3

Let us suppose, for example, that we wish to measure the current flow in a 10-in. cast-iron pipe, of which a length of 8 ft. is accessible. The surface of the pipe having been filed bright at two small spots 8 ft. apart, one lead of the millivoltmeter is applied firmly to each spot, and it is noted that the needle indicates a drop of, say 3 millivolts. Looking in the Table for Cast-Iron Pipes, opposite the Inside Diameter of 10 ins., and under the Distance between Points of Contact of 8 ft., we find that the current flowing on the pipe for each millivolt drop is 5 amperes. The actual drop noted was 3 millivolts, so that the actual current flowing was $5 \times 3 = 15$ amperes.

The Table for Wrought-iron Pipe would be used in exactly the same manner. The weights given in the table for cast-iron pipe are average weights per lineal foot of the plain body of standard cast-iron water pipe, without bell. The weight per lineal foot of such pipe as laid with bell would be about 10% greater. The weights for wrought-iron pipe are taken from maker's catalogue. Care should, of course, be taken to so locate the points of contact of the millivoltmeter wires that no bell nor joint is included between them.

As the work of examination of mains and measurements of current flow progresses, conditions, oftentimes entirely unanticipated, will arise; for stray currents, once released in the earth, are sad wanderers, and are frequently encountered where least expected. The investigator must then remember that the current will never fail to obey the laws of current flow, and will divide itself with unerring precision among all the paths offered to it, in quantities exactly proportional to the relative conductivities of those paths. If large currents bob up where little or none is expected, or small currents are found where large quantities are looked for, it simply means that the investigator has been forecasting results from wrong premises. If he keeps searching, his patience will probably be rewarded by the discovery of paths of unsuspected conductivity whose presence will entirely explain the wanderings of the current.

FIELD NOTES.

Great care should be taken to promptly and accurately record everything of value observed, and to exclude all irrelevant matter from the note book. The leaves of the note book should be ruled in squares, about 5 to the inch, and a rough sketch should be made of each point where the main is exposed. This sketch should clearly show the location, with the north at top of page, of the street lines, car tracks, if any, and pipes. There will usually be some specials or fittings exposed, and these should be sketched in, and sizes noted. The notes should record the date and hour of the observation, the character of soil, and of pavement, if any; the condition of the pipes examined, the depth of the deepest pits actually found; the difference of potential, if measured, between pipes and rails; and the drop of potential along the given length of pipe. Arrow heads in the sketch should show just where this drop was measured. The current can be calculated at the close of the day from the tables, and recorded in the note book. The notes should also show whether the pipes are positive or negative to the earth, or to any other pipes that may be exposed in the trench. Especial care should be devoted to examining joints for pittings or leaks. If lead or iron are visible as redeposited compounds in the soil, the fact should be recorded. While this list of points to be covered sounds long, practice will soon enable the superintendent to make very satisfactory sketches and field notes, and on the witness stand they will be indispensable.

The notes should be carefully preserved and it need hardly be added that to publish the results of the survey in advance of any legal action which might be based upon it, would be a most unwise proceeding.

DAMAGE CAUSED BY ELECTROLYSIS.

The injury caused by electrolysis may be divided into,

A.—Direct Damage.

B.—Incidental Damages.

Under the first head may be classed:

1. The injury caused to the mains and service pipes by currents which leave their outer surface wherever they are positive to the adjacent earth.

This injury goes on fastest in the territory near to the power station or to the points at which return feeders leave the rails for the power station. As the pipes are at times positive to the earth at points remote from these centers, the injury from such outside pittings takes place, though usually at a slower rate, at points distributed almost all over the system. Many actual cases of serious pittings have been found miles from the power station, and at long distances from the rails. Every member of this Association has seen so many pipes pitted on their outer surfaces, that it is not deemed worth while to introduce any of the hundreds of available photographs showing this damage.

It is possible, by careful examination at many points properly distributed over the system, to make a reasonably fair estimate of the extent to which the mains and service pipes have been damaged by this class of pitting. The last two large piping systems examined by the writer showed an average depreciation, all over the entire system of mains, and due only to outside pittings on the mains, of between 21 and 23%.

The depreciation from this cause can be expressed in percentages; but it must be borne in mind that the amount deduced from these percentages, if based on the actual original cost of laying the pipes, is by no means a fair measure even of the damage due to this class of pitting alone, for the cost of replacing single lengths of pipe piece-meal, as they break, is often many times the cost per lineal foot of laying the mains in the beginning. To the cost of the extra materials and labor required for the actual repairs, there is also to be added the labor of shutting off and draining the mains and the loss of water to the pipe owner; and as it is usually the case that mains are laid in advance of paving, there is, as a rule, the added expense of repaving the street over the pipe, and the difficulty and danger of working under increased congestion of traffic in the streets. The percentage of injury to service pipes due to pittings of a given depth is naturally greater than that to the mains, because the service pipes are thinner; the breakage of a main, on the other hand, is, of course, much more serious when it does occur than that of a service pipe.

2. Injury caused by pitting inside the mains near the joints; or on the outside of spigot ends, under the lead at the joints; or inside the sockets of bells, over the lead, or on the lead itself.

This class of injury is unquestionably the most serious, for it must occur whenever, in any part of the entire system, the mains are carrying current. There is no way of guarding against it, and no means of telling where it will occur first. The outside pittings in the body of the pipe may be seen by going to the expense of exposing the pipe. The joint pittings cannot be seen unless the pipe is cut open for inspection. The first result of these pittings is usually a small leak, which in sandy soil may run unnoticed for a long time. The escaping water finally cuts away the lead until the joint blows out, or else until the soil under the main is undermined so that the main settles and breaks. From the circumstances of the case, it is impossible to express in reasonably accurate figures the percentage of depreciation due to these joint pittings; but the writer has of late years found hundreds of instances of serious injury from this cause alone. Naturally the injury goes on most rapidly where the mains are carrying most current, and the territory in which the the worst joint pitting is found is, therefore, roughly speaking, a zone or belt surrounding the location of power station and return feeders, but at a considerable distance from them. This is explained by the fact that mains gather current at their outer ends up to the point, where, at the instant, there is no difference in potential between mains and rails, and lose it from this point in towards the power station, thus carrying the greatest current at about this temporary neutral point.

A striking instance of such joint pittings is shown by photographs (reproduced in Engineering News of Jan. 24, 1901), which clearly show joint pittings on the spigot ends of 16-in. pipes which were removed in the writer's presence in the spring of 1900. There were in all nearly 1,000 ft. of this pipe, which was about two miles from the power station, and which ran off at right angles to the track. It was always negative to the rails, and the current flowed along it from the spigot end of one pipe into the bell end of the next. No pits could be found anywhere on these pipes except near the positive side of each joint; but the spigot end of every single pipe was pitted, either on the inside or outside, or both, where the current left it.

The records of the water-works of which this pipe formed a part, show that from four years after the street railways started to operate by electricity and up to November, 1902, there were, in this stretch of main alone, six actual joint leaks requiring repairs, and 27 more similar leaks in the same main, nearly all in the same neighborhood.

The records also show over 70 similar joint leaks in a 30-in. main, in the same system; 4 in a comparatively short 20-in. main; and 41 in mains of smaller sizes, for none of which can any other cause but electrolysis be assigned.

The extraordinary frequency with which the lead was being blown out of the joints, especially of the 30-in. main, which was, for over a mile, the sole source of supply to the city, finally caused the Superintendent to put in special clamps, designed to hold the lead in its place. After the lead of a leaking joint had been thoroughly recaulked, and the joint proved absolutely tight under pressure, a steel band or clamp was bolted around the pipe in front of the lead in the joint, leaving a half-inch space between the clamp and the face of the lead. This space was then carefully filled by pouring in lead, hardened by adding solder, so that unless the clamp slipped the lead in the joint had no chance to blow out. This device proved perfectly effective against the blowing out of the lead; but it could not prevent the continued electrolytic action in the joint, as several of these clamped joints have since leaked so badly as to require additional repairs. Fresh, deep pittings were also found on the clamps themselves.

Under the head of incidental damages may be included: The loss of water; the destruction of pavements; and of car tracks on the streets; the settling of foundations of building, and the flooding of basements, and damage to the goods stored therein, by the escaping water; cutting

off of the water supply and fire protection from the territory affected; and the risk to lives and property of citizens as a result of any conflagration that might take place before the break could be repaired.

The actual damages to gas mains are exactly similar to those to water mains. The incidental damages resulting from gas explosions may possibly be even greater.

On Dec. 11, 1898, a 48-in. cast-iron main burst in Brooklyn. Some estimates placed the loss, nearly all of which would come under the head of incidental damages, at several hundred thousands of dollars. While these estimates were probably excessive, the actual damage, notwithstanding the fact that no fires occurred in the territory served by the main while the latter was being repaired, was certainly enormous.

Some of the experts who examined the main attributed its rupture to electrolysis. Whether this was, or was not, the cause is not to the point at present. The fact remains that every city whose mains carry current is exposed to the danger of similar disasters.

REMEDY.

These conditions call for a prompt, positive and absolutely effective remedy. The street railway people have proposed scores of remedies. Among those which have been suggested are the following: Glass water pipes, wooden water pipes, laying service pipes inside of a rubber hose, wrapping the water pipes in some sort of alleged insulating cloth, painting the pipes with patent paints, making insulating joints in the mains, increasing the conductivity of the joints by bonding around them, and so on. Apart from the fact that the pipe owner could hardly be expected to make over his plant in order to prevent its being damaged by the suggestors of these methods, the absurdity of all these remedies renders unnecessary further comment on them before any body of water-works men.

Forced to admit that it is impossible to keep the current off the mains so long as the rails are used as return conductors, the street railway people have suggested many other remedies, to be applied by them, with a view to reducing the damage to what they claim will be a "negligible amount." They say, in effect, to the pipe owner, "Let us alone, and we will cure your trouble. Your pipes have been breaking near the power station. We will rebond our tracks, and we will put in certain connections between your mains and return feeders that will reduce the difference of potential in the pipes in the district hitherto postitive, so that no more pipes shall break there." This proposition contains but one clause which can in any way benefit the pipe owner, and that is the rebonding of the rails. It is true that this would almost invariably be a first-rate business investment for the railway company; but as the pipe owner does not, or ought not to, wish anything but prosperity to the street car company, no objection ought on that score be raised to rebonding the rails.

But let us see how much actual benefit the pipe owner would derive from accepting this as a remedy for his injury. Let us assume that the total conductivity of the rails as a path for the return current is represented by the number 50, and that the total combined conductivity of the earth, the water pipe, gas pipes, and all the other conductors buried in the earth, is represented by the number 100. The current would then, broadly speaking, divide itself between the rails on the one hand and the earth and all the other conductors on the other, in the ratio of 50 to 100. Let us next take the violent assumption that the street railway people actually do so improve their bonding, and the still more violent assumption that they actually so maintain its efficiency when improved, that the conductivity of the rail path is doubled, and may be represented by the number 100; while the combined conductivity of the earth and of all the pipes and other conductors buried therein still remains the same, and is also represented by the number 100. The result would be, again speaking broadly, that one-half of the current would go back by the rails, and one-half by all other paths offered to it.

The net gain to the pipe owner would be that the current now on his pipes, would bear to the current which was there before the bonding was improved, the same relation which one-half bears to two-thirds; in other words, one-fourth of the current which the pipes were previously carrying would have been removed. Can any man claim that this would be reducing the injury to a negligible amount?

Every one of the other remedies embodied in the above proposal of the street railway companies involves some sort of connection between the pipes and the return conductors leading to the dynamo. These would also incidentally reduce the coal bill of the street railway company; but as before stated, the pipe owner ought not to object to them on that score. The relief which it is alleged will accrue to the pipe owners by their use, is the diminution of potential of the pipes in the normally positive district, and the stopping of breaks where they have actually been occurring with greatest frequency. It is true that by putting in these electrical connections between the mains and return conductors to the dynamo, the electrical conditions can be so changed as to reduce the potential of the pipes to some extent at certain points, though never to a negligible amount. But the inevitable result of every such connection is to increase the conductivity of the paths of which the pipes form a part, and to cause more current to flow on the pipes. This added flow of current will increase the injury at the joints all over the entire system. The effect of this joint injury has already been described, so that I need not dwell on it further here. It will suffice to say that the net result to the pipe owner, who might consent to such remedies, would, in the long run, be far more serious and widespread injury, than he has hitherto suffered.

There is, then, but one real remedy, and that is the complete removal of the current from the ground.

If it could be shown in court that the present system of conveying water through pipes was defective and dangerous; that the fluid conveyed leaked out at every joint, or that the pipes actually burst, interfering with traffic, destroying pavements, injuring street car tracks, endangering the foundations of neighboring buildings or depriving business districts of fire protection until the breaks could be repaired, and if it could be further shown that by the adoption of some other system of conveying this fluid the owners of water-works plants could not only stop all this injury and danger, relief from which would be had in no other way, but that they could therefore conduct their business at least as economically and profitably as before, no one will doubt that the court would order the pipe owners to adopt the safer system.

The analogy between this suppositious case of the pipe owners and the actual case of the railway companies seems to be complete in every respect. The current conveyed by the grounded returns of single trolley systems does, in obedience to the laws of fluid flow, leak off at every point of those returns at which the temptation presents itself, and this leakage, by injuring the water pipes, must inevitably result in exactly the above described injury and danger to the property of others.

That there is no known method by which owners of water and gas pipes, can themselves prevent injury to their property from single trolley currents is now admitted by every engineer of competent experience and knowledge of the subject of electrolysis. That the street car companies who cause the injury, can, at moderate cost, so change their constructon as to thereafter cease to cause the injury and to operate at least as successfully and economically as at present, has been thoroughly proven by years of experience with the double trolley systems here and abroad.

In all equity and justice the street car companies should make this change of their own free will. It is the writer's firm conviction, that to do so would be their very best business policy, and he believes that this conviction is shared by not a few of the fair-minded and far-sighted railway men. But if the street car companies do not voluntarily make the change, then they should certainly be compelled to do so.

NEW GEOLOGICAL ATLAS SHEETS have been published by the U. S. Geological Survey, as follows: Hammondsport (N. Y.), Quadrangle; Newburg (N. Y.), Quadrangle; Winthrop (Ia.), Quadrangle.

THE FAILURE OF THE OAKFORD PARK AND FORT PITT DAMS, NEAR JEANNETTE, PA.

By Willis Whited,* Assoc. M. Am. Soc. C. E.

On Brush Creek, about a mile northeast of Jeannette, Pa., the Pittsburg, McKeesport & Greensburg Traction Co. some years ago (1896) built a dam to form a pleasure lake as a part of Oakford Park. This dam was of puddled earth with a masonry spillway, and the height of the crest was about 15 ft. above the bottom of the lake, and 20 ft. above the bottom of the valley below. The embankment had a crest 8 ft. wide

FIG. 1. BREACH IN OAKFORD PARK DAM, LOOKING DOWN-STREAM.

and was about 350 ft. long, and both slopes were paved with a dry slope wall (12 ins. thick), part of which may be seen still standing in Fig. 1. The sketch, Fig. 2, shows the location of the spillway on the east shore. This spillway was 25 ft. long and its crest was about 3 ft. below the crest of the dam. Part of the spillway had been quarried out of the solid sandstone, and the rest of it was an embankment with a masonry heart-wall, and well paved slopes, flanked by a wing wall, shown in Figs. 1 and 3. The heart-wall extended beyond this wing wall a distance of 3 or 4 ft. into the earth embankment. The paving of the spillway was laid in mortar, and its good quality is well shown by the fact that, although a section 5 ft. square on the upstream side was undermined, it did not cave in.

The dam embankment was built up in 8-in. lay-

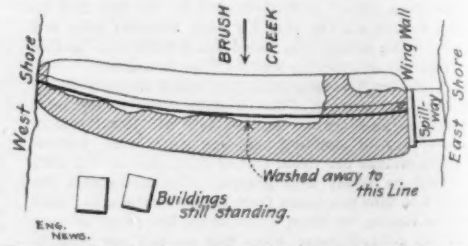


Fig. 2. Sketch Plan of Oakford Park Dam; Eroded Portion Hatched.

ers of good puddle. These layers stand out well, after erosion, as shown in Fig. 3. A small masonry heart-wall, 2 ft. thick and 3 to 4 ft. high, was built clear across the creek to prevent leakage under the dam.

Having a clear conception of the dam itself we may better understand its failure. Previously to July 5, the day of the failure, there had been

*Assistant Engineer, Department Public Works, Pittsburg, Pa.

heavy rains in western Pennsylvania, so that the ground was water soaked. About four o'clock in the afternoon of that day rain began to fall again at a time when there were many pleasure seekers in the park; and in a few hours, according to a local observer,* 5¼ ins. of rain fell. The result was that the spillway could not carry the flood, and the whole dam was topped by the water, resulting in its rapid failure. The excellent quality

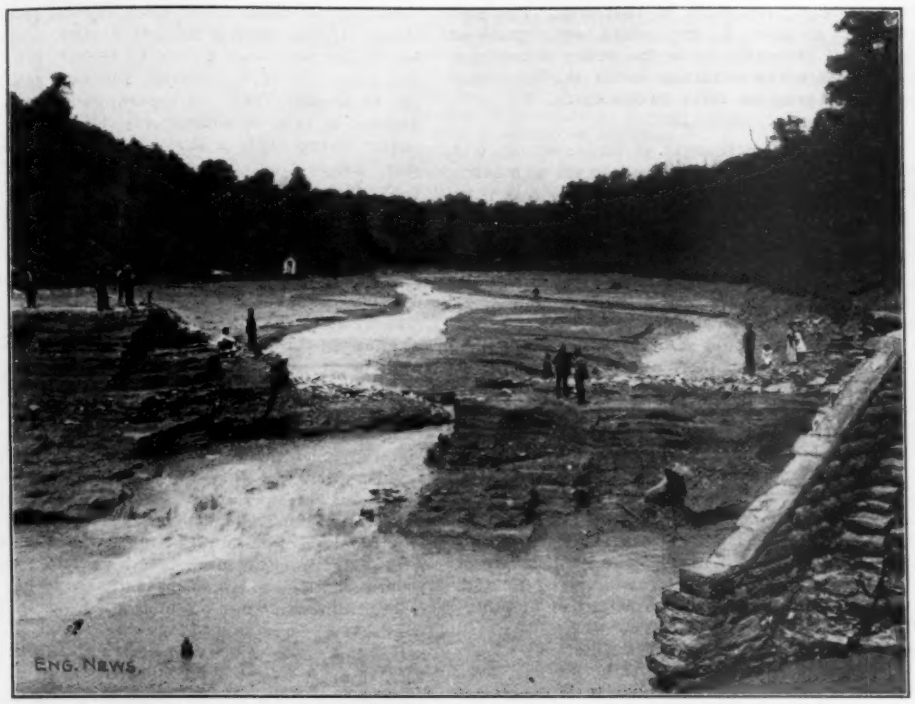


FIG. 3. BREACH IN OAKFORD PARK DAM; LOOKING UP-STREAM.

of the puddle is shown by the fact that no breach was opened until the whole downstream face of the dam had been washed away, as shown in Fig. 2. Finally, the embankment was breached near the spillway. In looking for highwater marks I found evidence in the grass on the hillside that the water had reached a level at least 2 or 3 ft. above the crest of the dam. I was told by employees of the park that it rose to a mark they showed me about 6 ft. above the crest; but in view of the fact that there are light wooden buildings belonging to the park immediately below the dam, and within a few yards of it, I should be inclined to doubt the correctness of that statement. I should judge that a torrent of water 6 ft. deep and 350 ft. wide rushing over a dam would have carried away ordinary buildings. These buildings are badly damaged, but are still standing.

There is a small crevasse at the west end of the dam, about 8 ft. wide and 4 ft. deep, but the main one is at the east end next to the spillway (Fig. 2), and is about 75 ft. wide and from 10 ft. to 20 ft. deep. The evidence is plain everywhere that the dam failed by erosion on the downstream side, and not by sliding; the downstream face is nearly vertical almost everywhere, due to the erosion.

At the coroner's inquest witnesses testified that the dam did not fail till two or three hours after the water began to flow over the crest. Allowing for the fact that minutes seem like hours, and that time observations are not the rule on similar occasions, I think there is excellent evidence that it was at least an hour. Whenever a break occurs it extends very rapidly. It is evident that the people had time to get out of the way of the flood, but it was raining very hard all the time, and the shelter houses were very near the dam, as is shown by one of the views, and people would be likely to stay in them as long as they could. If the downstream slope wall had been laid in mortar the dam would probably have stood.

THE FORT PITT DAM FAILURE.

About the same time that the Oakford Park Dam gave way, the Fort Pitt Dam also failed. This dam was built across the valley of Bull Run, and had failed once before in 1896. It lies at a point about half a mile north of Jeannette, and serves to impound water for a glass works. The Fort Pitt Dam was a small affair, about 175 ft. long, the crest being about 6 ft. higher than the bottom of the pond above. It was built of puddle, faced and topped with cinders from the neighboring glass works. These cinders were not very well compacted, and soon yielded when the water began to flow over the crest. There was a spillway with a plank floor 45 ft. wide and about 3 ft. below the crest of the dam. I could find nothing to show how high the water had risen above the crest of the dam, but I think it was hardly more than a few inches. The crevasse was about 90 ft. long and 8 to 10 ft. deep, measuring from the crest.

LOSS OF LIFE.

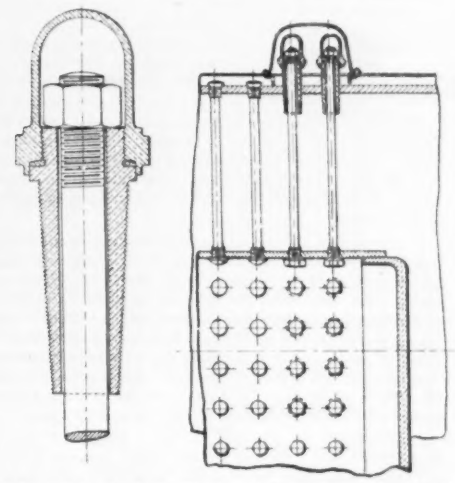
The flood waters from these two dams came together in Turtle Creek, and fortunately for the inhabitants of Jeannette, the Pennsylvania Railroad embankments cross both valleys. The culvert under the railroad at Brush Creek, about a mile below the dam, is 22 ft. span and about 16 ft. high; but, notwithstanding, the flood rose 10 to 15 ft. above the top of the culvert. Part of this rise, however, was caused by the culvert being partially obstructed by wreckage. Thirty or 40 ft. of the downstream end of this culvert was washed out, causing much damage to the embankment. But the railway embankment thus served to protect those people living below, on the south side. The total loss of life from both dam failures was about 25, and the property loss amounts to several hundred thousand dollars.

*Rev. Chas. M. Fraser, Pastor of the First Presbyterian Church, Jeannette, Pa.

ELECTRIC TOWAGE ON CANALS formed part of a paper by Mr. Gerald Fitz-Gibbon, M. Inst. C. E., presented to the late Engineering Conference of the Institution of Civil Engineers. The Galliot system was used on the Burgundy canals in 1894-97. It included an electric tricycle on the towing path, supplied with current from an overhead wire, and a rudder-motor. The bicycle weighed two tons and was capable of towing two barges loaded to 700 tons at a speed of 1¼ miles per hour. The current was supplied at 500 volts; and the cost of haulage is said to have been 0.038 d. per ton, or about half the cost of horse-haulage. The Gerard system, of Belgium, has been in operation since 1900 on the Charleroi Canal, 50 miles long. The system consists of a 2-ton four-wheel electric carriage, of 5 HP. nominal, fed by overhead wires; the current for the three-phase motor being taken through three separate trolleys. There are overhead three trolley wires supplying current at 600 volts, three feed wires carrying currents at 6,000 volts, and two telephone wires. The generating stations are 29 miles apart, with substations every three miles containing transformers for reducing the current to 600 volts. No data are given as to cost; and the author only says that while the cost remained about the same as for horse-haulage, the speed was double that of horses. The Gerard system is being tried in England on the River Lee Navigation.

AN ADJUSTABLE STAYBOLT FOR LOCOMOTIVE BOILERS.

In a note in the "Organ für die Fortschritte des Eisenbahnwesens," Mr. O. Busse, of Kopenhagen, Denmark, describes a new way of fastening staybolts into the shell of a locomotive boiler. His object is to provide for adjustment of the length of the staybolt, which becomes desirable after the repeated expanding of tube-ends in the tube-sheet has changed the shape of the fire-box at its forward end. This change of shape is of material amount only as far as the first one or two rows of staybolts, but within this distance it is large enough to call for adjustment of the staybolts. In order to make such adjustment possible, the outer ends of the staybolts are not screwed



Adjustable Staybolt End, and Manner of Application to Locomotive Boiler.

directly into the boiler shell, but pass through thimbles screwed into the shell, as shown in detail by the accompanying drawing. The staybolt is capped by a nut, which rests against the outside of the thimble; a cap screwed over the thimble, the joint being packed with asbestos, prevents leakage past the staybolt. A part longitudinal section of the boiler (shown to the right in our drawing) illustrates how the capped staybolts are used. Mr. Busse states that, as he found subsequent to his design of these staybolts, the Paris-Lyon-Mediterranean Railway has used a somewhat similar construction for flat-top boilers.

THE FOREIGN COMMERCE OF THE UNITED STATES for the fiscal year just ended exceeds that of any preceding year in our history. The total of imports and exports for 1903 is $2,445,610,417, as compared with $2,310,937,155 in 1900, the previous high record. The total of imports last year was $1,025,619,127, with $1,419,991,290 representing exports. The imports are the largest on record and the exports were only exceeded in 1901, when the value reached a total of $1,487,764,991. In 1893 the imports amounted to $866,400,922 and the exports to $847,665,194. The growth in imports for 1903 is very largely in material for use in manufacture.

TENSILE TESTS OF TIMBER may be made on simple prismatic pieces, instead of on pieces with enlarged ends, according to the experience of Mr. E. Palacio, of Buenos Aires, Argentina. In a large series of timber tests carried on at the University of Buenos Aires the tests pieces for the tensile tests were simple rectangular strips, 5 cm. × 2 cm. × 50 cm. (about 2 ins. × ¾ in. × 20 ins.), and the ends were held between the jaws of the testing machine by means of wooden wedges. The wedges had a bearing on the test-piece for a length of 12 cm. (4¾ ins.), thus leaving a free length of 10 ins. at the middle of the test-piece. All the specimens tested broke in this free length, and not under the wedges as might be anticipated. A summary of the tests, which covered over a score of different woods, will be found in our South American contemporary "La Ingenieria," of Buenos Aires, issue of May 31, et seq.

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In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 323 means that subscription is paid to the 32d week (that is the issue of Aug. 6) of the year 1903; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The completion of the underground public convenience station at San Francisco adds another to the many services which the Merchants' Association of San Francisco has rendered that city. It also adds to the small number of such accommodations to be found in American cities, and calls renewed attention to the remarkable contrast in this respect between our own and European municipalities. Outside of the park service it is rare indeed to find an American city that has established public water closets. Boston appears to have done the most in this respect, having a dozen or more stations in use, and New York City stands next with a much smaller number. The city of San Francisco, by accepting the gift of the Merchants' Association on June 29, is now included with the cities maintaining, although it did not itself provide, such accommodations. The moderate cost of the San Francisco station, and the appreciation of it immediately shown by the citizens, might well encourage other cities to provide such improvements. An illustrated description of the San Francisco station is given in "The Merchants' Association Review" of that city for July, 1903. Mr. L. M. King is secretary and superintendent of the association.

The annual controversy over the water rates is in progress at San Francisco. The Board of Supervisors, as usual, established the rates some time ago, and, as usual, the Spring Valley Water Co. is contesting the rates on the ground that a reasonable revenue will not result therefrom. A temporary injunction has been secured, pending a detailed presentation to the court of both sides of the controversy. The right of the supervisors to establish water rates yearly is a provision of the constitution, applicable throughout the State of California, but much as there is to be said in favor of public regulation of the rates charged by water and similar companies the California plan, at least as applied to San Francisco and Oakland, is far from satisfactory. A yearly readjustment of rates seems altogether too frequent, and any public regulation should be accompanied with public control of capitalization and full publicity of accounts. Unquestionably the yearly commotion over water rates at San Francisco is one of the strongest causes of the growing demand for municipal ownership in that city. The new charter, adopted a few years ago, declared municipal ownership to be the policy of the city, and water-works naturally heads the municipal ownership program there as elsewhere.

What would be thought if an American city should take such action in the interest of municipal esthetics as has recently been taken by Lübeck, Germany? That city has added to its building ordinances a provision that any structures to be built or rebuilt shall have all parts that are visible from public streets or squares constructed architecturally in such a manner as not to be a disfigurement nor to detract from the appearance of existing structures, especially historic buildings. Further, all signs, inscriptions or other advertising devices which would be disfigurements are prohibited. The enforcement of these provisions is, as usual in Europe, made the business of the police department. Any complaints or discussions arising are to be referred to a committee of three members of the city council.

The nearest if not the only approach to public regulation of street architecture in this country appears to have been made by the legislature of Massachusetts in behalf of the city of Boston; and that merely restricts the height of buildings in one or two special localities where very tall structures would dwarf public architecture. Even in Europe, where municipal esthetics has, here and there, gained a firm foothold, little regulation of the architecture of private buildings fronting on streets or squares has yet been attempted, save only as to height. But the time is certainly coming when street architecture will be a matter of grave concern in all the most progressive communities of the world. As those happy days approach beauty will gradually supplant bigness as a municipal ideal, and selfish individualism will yield to the common good.

HOW LARGE A PERCENTAGE SHOULD THE CONTRACTOR ALLOW FOR PROFIT?

After the actual cost of materials and of labor for a given piece of work has been estimated, the question arises as to what percentage should be added for profit. Generally this percentage is made to include an allowance for sundries and for risks that cannot be very closely foretold. Perhaps the most common allowance for profits is 15%, and civil engineers seem to think, as a rule, that 10 or 15% is always a fair allowance. At any rate we find it very usual to insert a clause in specifications wherein it is agreed to pay for all "extra-work" upon the basis of actual cost to the contractor, plus 15% (in some cases 10%) for profits. In this particular case, of course, 15% is ordinarily a fair allowance, for there is no element of uncertainty.

We wish, however, briefly to point out that no hard and fast rule should be used in making allowance for profits, and that where the cost of work is largely the wages paid, then a very liberal addition for profits should be made. In brick paving, for example, the cost of the cement, the sand, the stone, the brick, and other paving materials ordinarily forms more than 80% of the total cost of the paving. A contractor for brick paving can therefore figure very closely upon the total cost, for with reliable quotations on his materials he has left only the labor item upon which he can make a mistake. This labor item, being only 20% of the whole cost, evidently will not materially affect the total cost even if quite a large error occurs in estimating its amount. Hence on such work, when 15% is added for profits, the contractor is practically sure of making his full 15%.

On the other hand, let us take a case of masonry construction where the contractor has to quarry and dress his own stone, and where he has only one material to purchase, namely, cement. We see at once that the uncertainty of the actual cost of the work is great, for the efficiency of the quarrymen, cutters and masons cannot be definitely predicted. Strikes are liable to occur and thus materially add to the cost of the work. Finally, no contractor can be sure just what the inspector will call acceptable dressing of the stone—and this in spite of the most explicit specifications. If the locality be new to the contractor he is also somewhat at sea as to how the stone will come out of the quarry, and how readily it can be dressed. Is it not absurd, under such conditions, to talk of adding only 15% for profits? After having made a shrewd estimate of actual cost, the contractor, in such a case, would add from 20 to 50%, or even more, for profits—and unless work is extremely scarce he would be foolish to add less.

We see, therefore, that the percentage to be added for profits depends very largely upon whether the labor items predominate.

There is still another element to be considered in allowing for profits, and that is how much the total profits on prospective work will amount to at the end of the year. Many kinds of work, like the construction of macadam roads, can be carried on only during a few months of the year. The last report of the Massachusetts Highway Commission shows, for example, that steam rollers have each averaged about 100 working days in the year. Now if a road contractor can count upon only 100 days of work out of the 300 working days, it is perfectly clear that his daily profits must be several times as much as those of some other contractor who can work his men full time. In other words, his percentage of profits should be for more than the much-talked-of-but-seldom-seen 15%, if he is to get a fair return for his money, his plant, and his brains. Men just entering the contracting business are quite liable to overlook this last and exceedingly important fact, and as a consequence bid altogether too closely on such work. All the foregoing seems quite self-evident, but we have observed that the truth of some of the most self-evident propositions is learned only by severe experience.

SURVEYS FOR ELECTROLYSIS.

We take pleasure in reprinting, elsewhere in this issue, a paper on Surveys for Electrolysis, by Mr. D. H. Maury, which was read before the American Water-Works Association during its recent convention at Detroit. The paper is a practical instruction to a useful end—determining and mapping the conditions of stray-current flow in the ground for the purpose of studying the corrosion of underground metal structures by electrolytic action. What is generally given the brief name electrolysis is as live a subject to-day as it ever was, though at times there may have been more alarm over it than was needful. The subject is not highly alarming, but, on the other hand, it certainly deserves serious and constant consideration. It is to be remembered that electrolytic corrosion only rarely progresses at a rapid rate or produces great damage in a short time. But, on the other hand, it unfailingly works its effect in time; our electric railways have spread to every city, and the return currents from their operation (and also, in some cases, return currents due to electric arc-lighting systems) travel through the ground, passing along water and gas pipes and other available underground metal, and always produce pitting and general corrosion at few or many points along these pipes. Electric railway systems are still young, even the oldest of them, and as the damage from electrolytic corrosion is of slow growth and is hidden until a break occurs, we must consider that the cases where damage of this kind has been found are few compared with the number of such cases that the next ten or twenty years will bring. This prospect must be kept in view by all the parties interested, by the owner of the pipe, the owner of the stray current, and the public government which is charged with watching over the welfare of the community.

There are good reasons for hoping that in the end it will be a generally recognized principle that all return currents must be taken care of in other ways than by dumping them into the earth. They were not there originally, but are caused or produced artificially, and they are troublesome to other property and to each other. The strong street-railway current has already driven the telephone return out of the earth, not because the former has a better right to be there, but because, both of them outlaws, the weak and sensitive telephone return was forced, for self-protection, to flee before its mightier brother. The principal reason why the latter has not also been driven out of the earth, by the action of the law, is that to a large extent the law has not as yet recognized and defined all the property rights involved in the question. Indeed, many questions involving electric currents are construed on principles quite opposed to each other. Thus, when an American company which utilizes part of the water-power available at Niagara Falls proposed to construct a similar plant on Canadian ground and inter-connect the two plants electrically so as to permit of exchanging power between the two systems, the question came up whether the transfer, from one country to the other, of power in the form of electric current would be subject to import duties. Inquiry of the respective governments brought the answer that this would not be the case; the reason given was, according to a statement made before the American Institute of Electrical Engineers during its convention a year ago at Great Barrington, Mass., that electricity is intangible and could therefore not be taxed as an import. Here we have the assertion that electricity is not real property; but a contrary view has found repeated and strong judicial assertion in cases of prosecution for theft of current by tampering with meters or otherwise, in all of which cases it has been held that the offense is larceny pure and simple.

In time, no doubt, a full definition of the legal status of electric circuits and currents will be developed. Even now it seems clear that, where A owns an electric railway or lighting system, another person B may not connect wires to A's conductors or feeders; nor would he be permitted to interfere otherwise with the operation of A's system. The same principles of law should apply in the case reversed, where B owns underground metal structures, placed either in his own land or under public streets in virtue of and under the protection of a public franchise, then A has no right to make connections to the system of B, even if the connection be indirect as where A's current leaks over onto B's pipes. In either case the operation of the wire system (or pipe system) is under the protection of a public franchise, and no other person can be permitted to interfere with its operation or to injure the real property involved.

It is in anticipation of the time when the principles involved shall be clearly enounced, and for the necessary information of the interested parties in the meantime, that electrical surveys such as Mr. Maury describes should be undertaken. The author addressed himself primarily to water-works superintendents; but while many water-works are owned by the cities supplied, we would extend the plea for such surveys to all cities. Electrical surveys of this kind should be carried out by each city, through its engineering department, as fully and carefully as is the topographical survey of the city's territory. Unlike topographical features, the electrical contours and stream-flow gagings are ever shifting, and surveys should be repeated at frequent intervals, and carefully recorded on maps, so as to supply correct information of the average conditions during any given period. Some cities have had surveys of this kind carried out, usually by experts specially employed for the work. In Philadelphia, we are told, the city's engineers constantly watch over the potential differences due to the return of the street-railway, for the purpose of checking the working of the return feeder system which has been there adopted to minimize trouble from electrolysis. While a special expert may often be required in such surveys, the explicit and practical instruction given by Mr. Maury will enable every water-works superintendent, or the city's engineers, to carry out a fairly complete electrical survey and gain valuable information about the effect of stray currents on buried metal structures.

LETTERS TO THE EDITOR.

Engineering Impressionism; and the Manhattan Bridge.

Sir: A few days ago there appeared an article in one of the daily papers (The Evening Post), entitled "Political Impressionism," in which the writer deplored the fact that in politics, as well as in religion and other subjects of discussion, there is a general trend toward the acceptation of mere opinion, or what we may call saysoism, in place of reason and argument.

In the report of the Board of Experts on the Manhattan Bridge, you have a good example of *engineering impressionism*, which unfortunately is only too current among us. Many engineers appointed by capitalists or others to examine and report on a subject seem to think that all that is wanted is their bare opinion, and that their professional standing as experts settles the matter without further argument. Any criticism of such report from outsiders is too apt to be met with the reply, "Well, So-and-so is an expert on the subject, and he knows what he is talking about."

One may readily see to what abuses this follow-my-leader policy may lead. It is, of course, quite opposed to the scientific spirit. It enables the expert to shirk a critical and painstaking examination and substitute a mere superficial or off-hand guess—which is unquestionably a fraud on his employer. It satisfies nobody and gives rise to endless and profitless discussions and dissension among the interested parties, like that deprecated by the Engineering News. In short, it merely shifts the burden of the real decision from the engineer to the capitalist. And worse than all, it gives rise to accusations or suspicions of prejudice and favoritism, or worse, which may or may not be well founded.

The fact of the matter is, that the real value of an engineering report is to be found in its contents fully as much as, if not more than, in the reputation of its author. A really expert engineer, who has really and truly studied his subject, will not struggle to hide his knowledge and experience under the mantle of reconditeness; on the contrary, he will be bursting with reasons and arguments to sustain his position, or to demonstrate the impartiality of his conclusions. What would be thought of a judge, who, in a hotly contested lawsuit involving millions of dollars, merely wrote a six-line decision containing the customary formula and the sentence? A judge is obliged to state his reasons in self-defense, and an engineer ought to be obliged to do the same thing.

Descending from genus to species, it has already been pointed out that the reports of the Manhattan Bridge experts consist largely of unproved and eminently debatable assertions. There is one in particular which is of some importance; namely, "The chains have decided advantages in the accessibility of all parts for inspection, as well as in economy and rapidity of erection." I cannot see that any of the three branches of this assertion proves itself, but the first is particularly exceptionable. It is, in my opinion, just the other way; it is the cables that are practically thoroughly accessible for inspection, while the chains are not. A cable, once laid, is covered with a heavy coating of wire and then of well-tried protective paint, and so protected it is obviously proof against all reasonably conceivable sources of decay. It is substantially a unit, as much so as if made from one piece. The only possible exception is the crevices under the suspender straps, but such crevices are readily filled with paint, and, if necessary, the straps may be displaced or removed from time to time for inspection. In the eye-bar chain, on the contrary, there are innumerable crevices and cracks which invite capillary absorption and subsequent corrosion, and which cannot be completely filled with or covered by paint, nor yet are open to inspection. How do the experts propose to inspect the condition of the pins?—which, by the way, cannot pretend to be made as uniform in quality as cable-wire. And yet the failure of a single pin means the failure of the chain.

Aside from all this, there is the very important consideration of cost of maintenance, to which the expert report is oblivious. The cost of painting an eye-bar chain, both in material and labor, is far in excess of the cost of painting a cable of the same strength, and, when done, the job is in nine cases out of ten imperfect, owing, as above stated, to the difficulty of access. This means the concomitant increased opportunity for municipal incompetence and corruption, and increased danger of an unexampled catastrophe. Do the supposed great, but (to the public) invisible advantages of the chain structure outweigh not merely a third higher first cost, but also the capitalized sum due to increased cost of maintenance, and why?

There is yet another consideration of great importance which seems to have been forgotten by everybody. I refer to architectural appearance. I think it will be generally admitted that a chain-bridge is a very ugly thing—excusable only on grounds of engineering expediency. In foreign cities architectural quality is always a primary consideration, but in America, particularly New York, the money-making mania has reduced structural engineering to bare utilitarianism. Surely New York is ugly enough already, and it is bad enough to have skeleton-bridge-towers, without the added eyesore of a chain-bridge.

To relegate the question of eye-bars vs. cable to the political arena, like the tariff, would be not simply unfortunate—it would be preposterous. The public know nothing of the merits of the matter. It was just this question that the Board of Experts were appointed and paid to determine, and it is just this that they have not done. To start out to build a ten-million-dollar bridge with no further information as to cost than we have in these reports would be an unexampled piece of engineering folly—not equaled even by the attempt made in Congress some years ago to appropriate $5,000,000 to start the construction of the Nicaragua Canal, for in that case there were at least extant some estimates more or less definite as to its cost.

Clearly the proper course for the Mayor is to hand back the report with the request that the missing information be supplied. What that information is ought not to be necessary to point out to an engineer, but if necessary, a series of "whys" referring to the unsupported statements of the report ought to go a long way towards enlightening them. Is it necessary to say that before doing anything we should have a detailed estimate of cost of each proposed construction with the possibilities in each case accurately ascertained and stated, together with the sources of information? Such a report would cover more than one sheet of paper. A really impartial engineering report, properly prepared, leaves no handle for charges of favoritism or corruption.

George W. Colles, M. E.,
Chief Engineer, Marion & Marion.
Montreal, Canada, July, 13, 1903.

(An engineering report should not be condemned because it does not follow the lines of a judicial decision, unless the engineer or engineers were engaged to serve in a judicial, rather than an advisory capacity. In other words, both capitalists and city officials may engage either engineers or lawyers to give a yes-or-no opinion. In such cases the opinions are to be considered as given for the benefit of laymen, rather than of the members of the engineering or legal professions. Whether or not Mayor Low wanted an advisory or a judicial opinion, and whether he wished what he ought, or got what he wished, we do not attempt to say.

It is only fair to say that Mr. Lindenthal is one of the comparatively few engineers who has recognized the claims of architecture in bridge design. Attention should also be called to the fact that New York City has a Municipal Art Commission to whom all designs for public structures are or may be submitted. The design of the bridge has been approved by the commission except the decoration upon the towers.—Ed.)

A Newspaper Idea of the Fitness of Practicing Engineers for Places on Commissions.

Sir: Let me call your attention to the inclosed. I have long known that a sentiment of the sort stated was prevalent in the United States public mind, but I have never before known of its having been so bluntly, yes, brutally, expressed.

I have above spoken of the United States public mind, because the United States and Great Britain are the only countries where dry goods merchants, saloon keepers and what not, are set to work to learn about engineering works and how to build them by virtue of appointments on commissions, and are then set to supervise the work of engineers. Even in the United States the practice is not universal. It does not obtain in the conduct of public works built by the Corps of Engineers, United States Army, nor does it obtain in the conduct of the construction department of successful corporations like the Pennsylvania Railroad, for instance, which has had a series of civil engineers, President and Vice-Presidents of the road. It is unknown on the continent of Europe.

It should be stopped in the United States in the interests of good and economical work. For example: Would the work of the New York Aqueduct Commission for the past fifteen years have been done better or worse than it has been done, if there had been a commission composed of engineers? Yours very truly,

Clemens Herschel.
2 Wall St., New York City, July 16, 1903.

(The enclosure was a clipping from the Boston "Advertiser" of July 10, relating to appointments

on the permanent Charles River Dam Commission. Among other things the "Advertiser" said:

The importance of the Charles River dam as an engineering project demands that somebody with a comprehensive knowledge of all the problems to be met should be chairman of the commission, somebody who would be able to decide offhand the greatest problems.

It is not that an engineer is needed. *On the contrary experience has proved that the place for an engineer is on the payrolls, not on the board.* (Italics Mr. Herschel's.)

But while no practicing engineer is big enough for the place, all agree that the man for chairman must be a man as big and as knowledgeable as Pres. Pritchett of Tech., for example.

We do not think that many city dailies have such ideas or use such a mode of expressing them.—Ed.)

Meeting of the American Society for Testing Materials.—Corrections.

Sir: Will you kindly allow me to call the attention of your readers to some inaccuracies in your account of the recent meeting of the American Society for Testing Materials, as published in your issue of July 9?

I did not say that the over-flow method for the casting of pipeless ingots was being introduced at an open hearth plant and would shortly be introduced at a Bessemer plant. I did say, however, that the method was being installed by the Simonds Mfg. Co. of Chicago; that trial experiments were under way to ascertain its value in casting open-hearth steel ingots, and that similar experiments would soon be started in connection with the casting of Bessemer steel ingots.

I did not say in reply to a question, that all the bad rails came from ingots having a hollow top, nor was that question asked, but I did say that all rails exhibiting, after etching, the appearance shown on the diagram, were piped rails, and I also expressed the opinion that a great majority of the rail failures were due to the presence of this defect.

Your reporter, alluding to the thermo-magnetic selector described by Mr. Jasper Whiting and me, says that this invention was severely criticised. I believe that this statement will be a surprise to all the persons who were present when the paper was read and discussed. It is my impression that instead of being severely criticised, it was quite favorably received. Indeed, it seems to me, that reasonable severe criticism of this instrument is quite inconceivable. It was argued by some members that the rail could be kept before the final pass for a time sufficient to make it magnetic, but this is a trick which can be readily prevented, and the consumer will see to it that it is not done. It does not in any way imply a weakness in the instrument described. This point is so well understood, both by manufacturers and consumers, that it would be superfluous to insist upon it.

I am not sending you these lines in any spirit of criticism, for I fully realize how difficult a task it is for a correspondent to give an absolutely accurate account, even as to substance only, of an animated and prolonged discussion. I remain, dear sir,

Very truly yours, Albert Sauveur.

446 Tremont St., Boston, July, 1903.

(The statement that the thermo-magnetic selector was severely criticised was based on the remarks actually made at the convention; but, of course, opinions as to the severity of criticism may differ.—Ed.)

Running a Transition Spiral.

Sir: In issue of July 2 you print a letter from Mr. R. S. Webster in reference to a spiral curve you say is Holbrook's.

This curve has been used by this road since 1897 when it was first tried here by the writer, at request of Mr. Otis Weeks, as that time an Assistant Roadmaster. If I remember correctly, Mr. Weeks obtained the tables, etc., from the Burlington Railroad.

The curve has been used here for seven years, and gives good results. We use it as readily on curves of odd degrees and minutes as on even degrees, and use chords from 10 to 50 ft. in length.

After obtaining the intersection angle and deciding where to get the new curve, we look on the table for a spiral which will most nearly fill the conditions, keeping in mind we shall run our central curve on an offset to correspond.

From my notes I find the following example: On a curve of 3° 48′ with I = 26° 17′, I decided to use a spiral of 35-ft. chords. I find

length of spiral = $35 \times 3^{48}/_{60}$, or $35 \times 3.8 = 133' = l$.

Next I want the shift or offset; from properties of curve (see Fig. 1) it is twice the tangential offset at the middle of the spiral. We find this as follows:

$$A = \frac{\text{(No. sub. chd. pt.)}^2 \text{ (lgth chd.)}}{10} = \frac{\left(\frac{3.8}{2}\right)^2 35}{10} = 12.6'. \quad (1)$$

$\frac{1}{2}\, s = (\sin 12.6')\ 66.5 = .244', \quad \therefore \ s = .49'.$

Now we put in sights on our tangents on the offset as at B. S. and B′. S′. Our tangent distance must be corrected (assuming we measure it from the original P.I.) by the amount

$x = (\tan \frac{1}{2} I),\ s = (\tan 13° 08.5')\ 49 = .11.$

After measuring in the P. C. and P. T. we place points at P. S. and P′. S′, each on original tangent and a distance $\frac{1}{2}$ l beyond them. With transit at P. C., on offset tangent, we run in a simple curve placing points at P. C. C. and P′. C′. C′., both = $\frac{1}{2}$ l from P. C. and P. T. We then return to P. S. and with a back-sight on original tangent set points on spiral by formula (1)

$$\text{First point} = \frac{1^2 \times 35}{10} = 3.5'.$$

$$\text{Second} \quad " = \frac{2^2 \times 35}{10} = 14'.$$

$$\text{Third} \quad " = \frac{3^2 \times 35}{10} = 31.5'.$$

$$\text{Fourth} \quad " = \frac{3.8^2 \times 35}{10} = 50.5'.$$

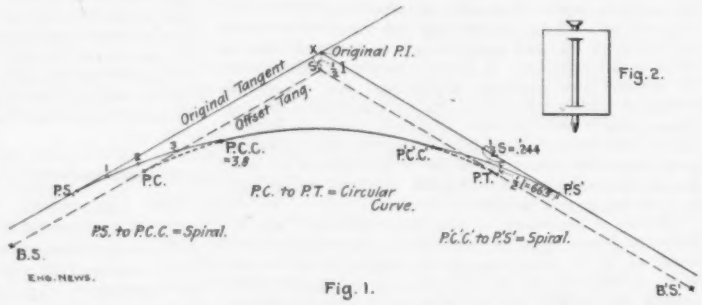

Fig. 1.

Fig. 2.

The fourth point should coincide with P. C. C., thus giving a check.

Instead of keeping a rodman at B. S. we put up a nail with a paper, as in Fig. 2. This we find a simple and convenient way, saving many steps. Yours truly,

H. J. Wild,
Assistant Engineer, Maine Central R. R.

Wiscasset, Me., July 7, 1903.

Riveted Joints Under Eccentric Load: Another Phase.

Sir: There have appeared in your journal recently some interesting letters in relation to the shearing stresses on rivets in joints eccentrically loaded. I should be glad to learn through your columns whether the vertical component of these stresses is the same in all rivets in any given vertical row as has been assumed, or do the interior rivets, which receive less of the horizontal force get a larger portion of the vertical load. The fact that material toward the neutral axis of a beam receives less bending stress but greater shear than material near the top or bottom of the beam has been considered a very economical law, and it naturally suggests the above question. Respectfully,

John L. Hall.

1553 Monadnock Block, Chicago, Ill., July 18, 1903.

(We shall be glad to have our readers discuss this phase of the problem of riveted connections in torsional shear. Without forestalling any of the discussion we would make two suggestions: First, we know but little as to the actual distribution of load among the different rivets in a joint, no matter how simple be the stress which is applied to the joint. Second, in connection with eccentric riveted joints the best principle on which to go is "Don't build them." Of course there are cases where it is not practicable to avoid such connections, but there are very many other cases where they can be avoided without ext a expense, if the principle is kept in mind.—Ed.)

A LARGE STEAM TURBINE DRIVING TWO GENerators has been built by the Swiss firm of Brown, Boveri & Co. for the Electric Co. of Essen, Germany. The turbine, which is of the Parsons type, has a capacity of 10,000 HP.; direct-connected to it are a direct-current dynamo of 1,500 KW. capacity at 600 volts, and a polyphase generator of 5,000 KW. output, at 5,000 volts pressure. The guaranteed efficiency of the set is one kilowatt-hour for 7 kg. (15.4 lb.) steam.

AN IMPROVED STEAM-HEATING SYSTEM.

Among the various systems of central heating of buildings, that of direct radiation from steam radiators is one of the most generally useful. It is so convenient and efficient a system that any improvement tending to bring it nearer to perfection in operation is to be welcomed. The main fault of steam heating is its inherently imperfect regulation, which makes it practically impossible to adjust any one radiator to the momentary requirements of the room which it serves. A recent modification of the system is designed to remedy this fault, and appears to be well suited to the purpose. It is quite simple, involving merely a slight change in the piping and the substitution of a new control valve and an automatic drain valve, in place of the globe valves and the air valve of ordinary steam radiators.

In present systems of steam heating a main steam supply pipe sends branches to the various radiators, and these branches have a globe valve at the radiator for regulating the flow of steam; there is usually a return branch connecting the radiator with a main return leading to the boiler, through which the water of condensation drains off and by which any uncondensed steam is returned to the boiler. Now, when steam in such a system enters a radiator, it must first force out the air contained in the radiator. For this

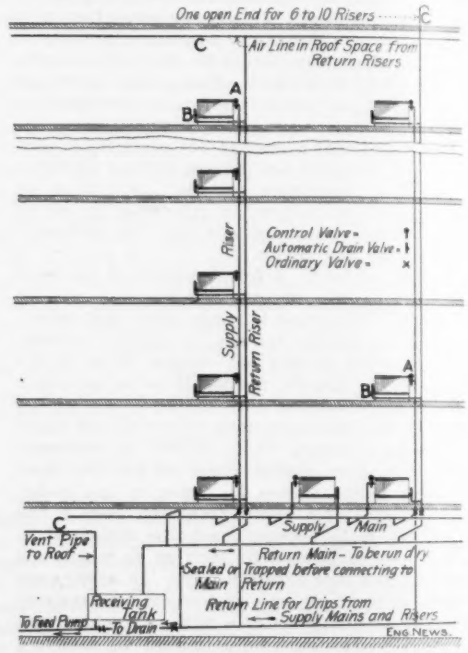

Fig. 1. Sketch of Piping for "Thermograde" System of Steam Heating.

Thermograde Valve Co., Boston, Mass., Makers.

purpose an automatic air valve is attached to the radiator, which is open for the passage of air, but which is closed by an expanding member as soon as the hot steam reaches it. It is usually found necessary to provide the air valve with a drip pipe to carry off any condensed water. This same air valve also allows air to be drawn into the radiator when steam is shut off, thereby preventing the formation of a vacuum in the radiator. Such a system works properly when all radiator valves are full open. But suppose less heat is desired in one of the rooms, and its radiator is partly shut off; then the steam condensing within that radiator produces a partial vacuum which tends to draw steam from the common return, the latter being filled with excess steam from the other radiators. Thus the desired regulation of the one radiator is not attained. Moreover, the reverse current of steam in the return branch of the radiator prevents proper draining of the condensation, and often causes violent waterhammer. A similar action on starting a radiator often has the effect that the larger part of the radiator remains filled with air, so that it cannot supply the proper amount of heat.

What is called the "Thermograde" system is intended to overcome the faults of the ordinary steam-heating system. It comprises a radiator,

a steam supply pipe fitted with a "Thermograde" control valve at the radiator, a return branch fitted with an automatic drain valve, and a permanent air vent in the return pipe. The control valve regulates the amount of steam flowing into the radiator. The drain valve allows all air and water of condensation to escape from the radiator, but prevents the passage of steam. The return pipe being kept free from steam, and having an air vent, it is always at atmospheric pressure; therefore, with constant pressure in the supply system, there is always a constant, positive pressure through every radiator. This ensures a regular supply of heat to the radiators even at low-pressure steam supply, and the "Thermograde" system is therefore designed to work on low-pressure steam.

A sketch of the piping arrangement in the

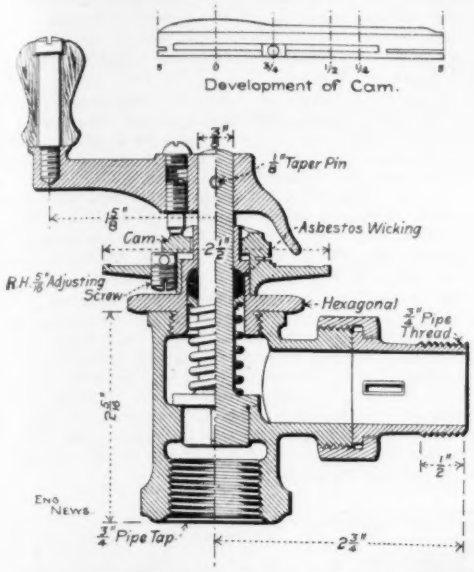

Fig. 2. Control Valve at Radiator. "a." Developed Sketch of Cam.

"Thermograde" steam-heating system is shown in Fig. 1, herewith. As the sketch shows, the steam supply pipe enters the radiator at the top, so that the control valve, A, is conveniently accessible; the steam entering at the top ensures that the air is driven out when the radiator is started. The automatic drain valve, B, is connected to the bottom of the radiator (the "hot-water" type of radiator is used). The vent pipe connected to the return is shown at C.

The two valves, A and B, may be readily understood from the detail sections, Figs. 2 and 3. The control valve is a flat-seated lift valve; it is operated by turning the handle, which rides over the upper surface of a circular cam on top of the valve casing. Less than one revolution of the handle gives the maximum opening. A developed view of the cam is shown at a, Fig. 2. As will be seen, the upper surface consists of a portion having uniform flat slope, and a portion rising more suddenly; the former portion is the cam surface for regular operation, while the larger opening given by the sudden rise in the cam is to be used only for special purposes, such as rapidly heating up a radiator. A circular dial on top of the valve, over which travels a pointer on the handle, indicates the degree of opening. When the valve is "full" open, it admits to the radiator just enough steam to fill it, i. e., it supplies as much steam per second as the whole radiator surface can condense in a second. Evidently when the valve opening is only half of full, the steam supplied will heat only the first half of the radiator, while the second half of the radiator simply conducts the condensed water to the drain valve, whence it flows by way of the return pipe back to the boiler. Any desired regulation is thus possible, and as the return pipe is vented there can never be back-pressure on the radiator or reversed circulation in any part of the system.

Fig. 3. is a section of the automatic drain valve. The casing contains a long zinc tube, at the lower end of which is a valve. When hot steam surrounds the zinc tube, the latter expands and closes the valve, thereby shutting off connection between the radiator and the drain pipe. On cooling, the zinc tube contracts and again opens the valve. Condensed water or entrapped air can then pass out from the radiator into the return pipe. As the water may be hot, a set of drain holes is provided in the lower part of the zinc tube, so that no water can rise around the zinc tube. When steam enters the valve, however, it rises around the tube and passes into the tube through holes near the top, thus effectually heating the tube and closing the valve. In order to allow for different degrees of expansion of the tube, its upper end bears against a spring which takes up all excess of expansion over what is necessary to close the valve. A stem attached to the top of the tube has a nut at its upper end

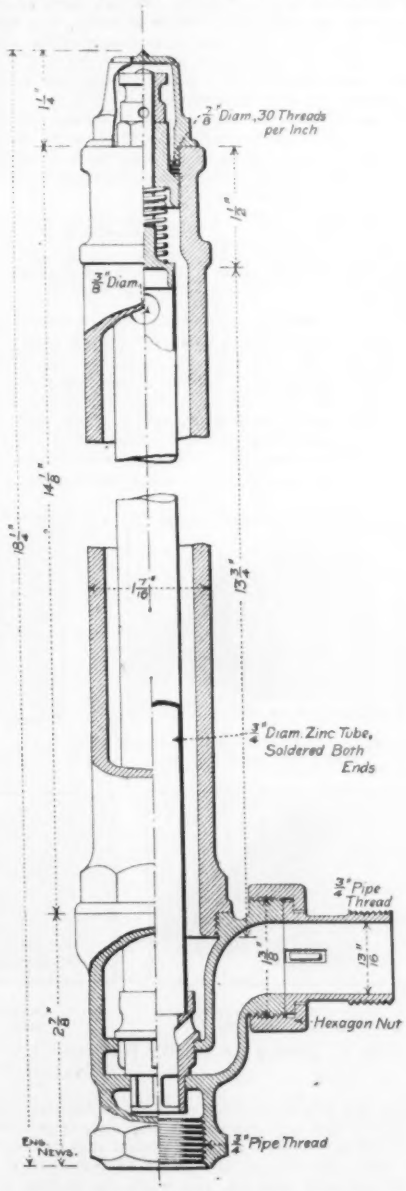

Fig. 3. Automatic Drain Valve at Radiator.

which bears on a seat on the casing; this nut allows of proper adjustment of the valve.

The appliances for "Thermograde" heating systems are made by the Thermograde Valve Co., of 100 Boylston St., Boston, Mass. The control and drain valves are made in various sizes to suit the capacity of the radiators. These sizes are shown in the accompanying table, which is based on a steam pressure of 2½ lbs. gage, which corresponds to a temperature of about 220° F.

Table of Sizes of Radiators, Valves and Connections.

Radiator surface, sq. ft.	Pipe thread. Control valve.	Pipe thread. Drain valve.	Run-outs from risers. Supply.	Run-outs from risers. Return.
0 to 20.....	½-in.	½-in.	¾-in.	¾-in.
21 " 40.....	¾-in.	¾-in.	1-in.	¾-in.
41 " 72.....	1-in.	¾-in.	1¼-in.	1-in.
73 " 100.....	1¼-in.	¾-in.	1½-in.	1-in.
101 " 150.....	1¼-in.	1-in.	1½-in.	1-in.

SOUNDNESS TESTS OF PORTLAND CEMENT.*

By W. P. Taylor, Junr. Am. Soc. C. E.†

For all purposes of construction a good cement must possess two essential qualities, strength and durability, and of the two the second is by far the more important. Few, if any cements, provided they are well handled, will fail because of lack of strength alone, so it may be generally stated that the chief purpose of the testing of cement is to determine its permanency, and yet less is probably known concerning the various tests for soundness than any of the others, and certainly no test is more frequently abused.

The most important factor operating in a cement to cause unsoundness is an excess of lime, either free or loosely combined, which has not had opportunity to become sufficiently hydrated. The presence of this lime may be due to incorrect proportioning, to underburning, to lack of seasoning, or to coarseness of grinding, which prevents perfect hydration. An excess of alkalies is also sometimes responsible for disintegration, while the presence of sulphate of lime acts in the opposite direction and tends to make good an otherwise unsound cement, at least as far as laboratory tests are concerned.

For determining soundness in Portland cements three general forms of test have been used: (1) Direct measurement of expansion. (2) Normal tests. (3) Accelerated tests.

In this country, direct measurement of expansion has never been extensively used, although abroad it has been, and is even still, occasionally employed as a test for the determination of durability, in spite of the fact that it has been shown that a cement may give a high expansion as a whole and yet be entirely free from any tendency to disintegration. The old "lamp chimney" test is the only form of this determination ever employed at present, and its use is rapidly dying out as the properties of cement are becoming better known.

Tests of soundness are therefore ordinarily limited to the normal and accelerated tests on pats, cakes, and briquettes of neat cement. The normal test in air and water is unquestionably the only perfectly fair method of determining the permanency of a cement, yet in practice, the element of time usually makes imperative the use of some form of accelerated test, which is supposed to hasten any expansive action, and to cause any possible failure of the material in a few hours, instead of in the weeks or months usually required for a normal pat to develop unsoundness.

The most common forms of accelerated test used are:

(1) The boiling test.
(2) The steam test.
(3) The hot water test.
(4) The flame test.
(5) The kiln test.
(6) Tests under pressure of steam, hot air or hot water.
(7) Strength tests of briquettes kept under some of these conditions compared with normal briquettes.

Of these tests the first three—those in steam, hot water, and boiling water—are by far the most important, not necessarily on account of their accuracy or reliability, but because of their almost universal use.

The Philadelphia Testing Laboratories have, in the last few years, had opportunity to investigate very thoroughly the action of cements under accelerated tests, and owing to their rather unusual facilities regarding the quantity and the variety of tests made, have accumulated some very interesting data, some of which will be given here. The records of the laboratory not only include a full series of physical tests, but also chemical analyses, tests of the strength of the concrete as used, and also records of the actual condition of the materials as found in the work.

In regular routine the accelerated test is made in boiling water on cakes of cement in the form of a small egg about 1 in. on its long diameter, which are kept in moist air for 24 hours, then placed in cold water which is gradually raised to the boiling point and maintained at that temperature for three hours, after which the specimens are removed and examined. Tests in steam, hot water, and in combinations of these treatments, for varying lengths of time and for varying ages of the specimens are also frequently made for purposes of comparison, and for general investigation.

The condition in a cement most affecting the result of an accelerated test is its age, or the amount of seasoning it has undergone. Every cement, no matter how well proportioned and burned, will contain at least a small amount of free or loosely combined lime, which will usually cause unsoundness if used or tested at once. This lime however will hydrate in a very short time on exposure to the air, thus rendering it inert and preventing any expansive action. It will therefore be found in a large majority of cases that if a cement failing in the accelerated tests be stored for 2 or 3 weeks, this unsoundness will disappear, and the cement pass the tests with ease. A typical case of this is shown in Table I. It will be noticed in this case that the cement has been made

*A paper read before the Cement Section of the American Society for Testing Materials at the Annual Meeting, July 3, 1903.

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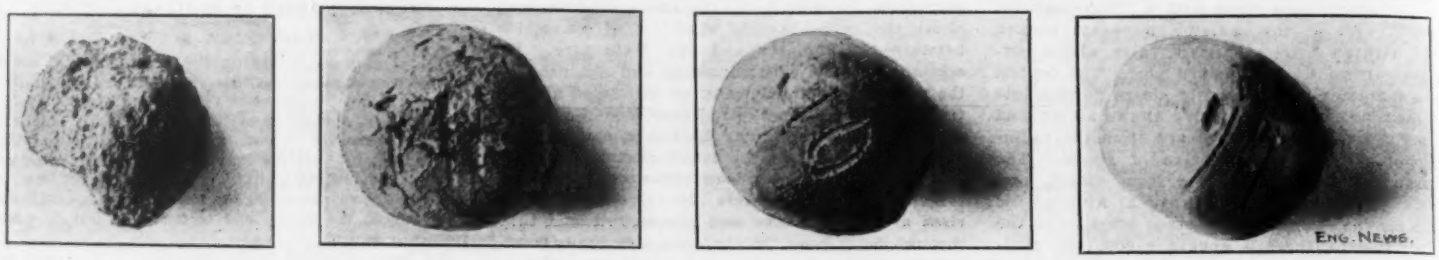


1 week old. 2 weeks old. 3 weeks old. 5 weeks old.

FIG. 1. CAKES OF CEMENT OF DIFFERENT AGES SUBJECTED TO THE BOILING TEST. (TABLE I.)

thoroughly sound by a seasoning of 5 weeks. The early strength values of the neat tests are also seen to fall off decidedly, while the sand tests generally show a slight increase.

Coarseness of grinding is also a frequent cause of unsoundness for the reason that the larger particles are not readily susceptible to hydration, and contain for a long period of time expansive elements which very rapidly develop a disintegrating action when treated in the accelerated tests. Table II. shows a typical instance of this action.

The objection most frequently made to the accelerated tests, and particularly to the boiling test, is the great variance in the methods used; different laboratories using different forms of test piece, and different periods of time before the test and for its duration. The variance in the results obtained under these several methods is, however, far less than it is generally supposed. The form of the test piece has practically little or no influence on the results, whether it be a cake, a ball, a wedge, or a pat, if the duration of test be sufficient. In a large number of tests made recently by the writer to determine how the results obtained from test pieces in the forms of pats and eggs varied, no differences were observed except in one instance where the pat seemed to show a slight checking while the egg remained sound. The only advantage that the pat has over the other form is that curvature can be readily ascertained, but a mere curvature of the pat should not be considered as a failure in boiling unless accompanied by checking. The requirement sometimes given that a pat should not leave the glass in boiling is not reasonable, as a small amount of expansion may be naturally considered normal.

The greatest difference in the methods of conducting the boiling test probably lies in the duration of the treatment, different specifications requiring the test to be made from one to as high as 48 hours. To determine the effect of different lengths of treatment a large number of tests on different cements were made and the time at which failure occurred was observed. In these tests it was found that of those samples which did not pass the test, 22% failed in the first half-hour; 57% failed in the first hour; 85% failed in 2 hours; 96% in 3 hours, and 99% in 4 hours. Only one per cent. of the tests that failed developed this action in over 4 hours, although many of them were carried up to 24, and a few to 48 hours; thus showing generally that a test piece of cement standing 3 or 4 hours of boiling will almost invariably stand a much greater length of time, and also that at least 3 or 4 hours should always be allowed for the test.

The time allowed for the specimen to harden before it is tested may cause considerable differences in the results, but if it always be given time to fully develop hard set the differences will be slight. Pats of cement allowed more than about 12 hours to harden will, if unsound, fail when tested by boiling at almost any time in the future. The writer has seen normal pats as old as six months and apparently perfectly sound, which when put through the boiling test, showed a failure almost identical to that obtained on the original test six months previously. If, however, the specimen is tested before it has fully hardened, the differences obtained in the results are often very decided, and curiously enough may operate in either direction—that is to say, a pat of cement may fail more readily when one hour old than when 24 hours old, or a one-hour pat may pass the test, while the 24-hour pat may fail. The reason for this action is by no means apparent, but it may be observed that in the ordinary case of the cement high in free lime from underburning the failure will usually be more marked in the fresher specimens, and that in the more infrequent case of the cement normally burned but high in lime by reason of poor proportioning the failure is often more marked in the older specimens. It would seem in this case that the cement was sufficiently strong to retain coherence in the test although insufficiently hardened, and that in this condition the lime was capable of becoming hydrated without causing disintegration.

For the same reasons, a treatment of the specimen in a bath of steam before immersion in boiling water is generally less severe than if the specimen be boiled without this treatment, particularly so if the test be made before the test piece has become fully hardened.

It is also evident from the foregoing that tests made in steam alone without subsequent immersion in hot or boiling water may often give rise to erroneous conclusions regarding the results, especially if the specimens be tested soon after making.

We now come to the very important question of the relation of the boiling tests to the other tests for soundness and strength as made in the laboratory. No one who has had much experience with the boiling test questions that although it is by no means infallible, the results obtained from it are generally corroborated by either the tensile tests or the normal tests for soundness. The writer has recently compiled some data in regard to this point covering over a thousand tests on many varieties of cements with the following results:

Of all samples failing to pass the boiling test 34% of them developed checking or curvature in the normal pats—or a loss of strength in less than 28 days. Of those samples that failed in the boiling test but remained sound at 28 days, 3% of the normal pats showed checking or abnormal curvature in 2 months; 7% in 3 months; 10% in 4 months; 26% in 6 months, and 48% in 1 year; and of these same samples 37% showed a falling off in tensile strength in 2 months; 39% in 3 months; 52% in 4 months;

TABLE I.—Effect of Age of Cement on Results of Boiling Test.

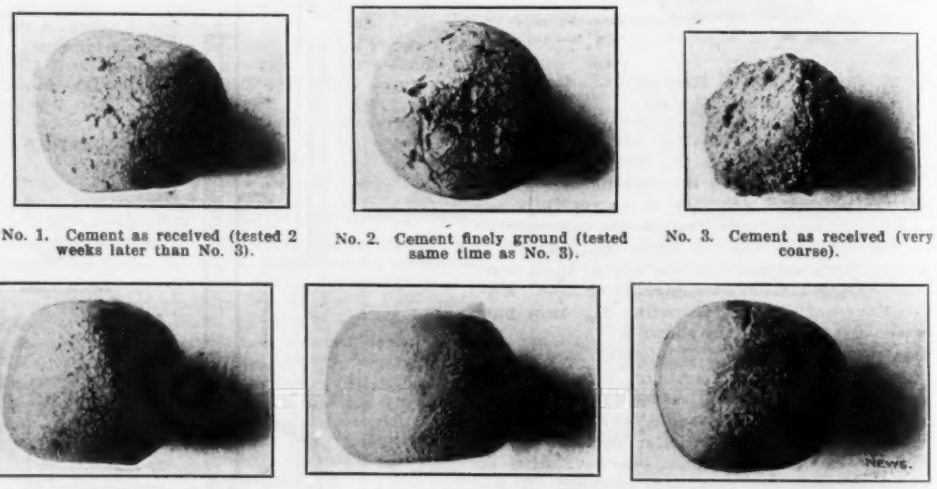
Age of cement when tested.	Tensile strength—Neat—1 day.	Tensile strength—Neat—7 days.	Tensile strength—Neat—28 days.	Tensile strength—1:3 sand—7 days.	Tensile strength—1:3 sand—28 days.	Normal pat tests. 28 days in air.	Normal pat tests. 28 days in water.	Boiling test.
1 week	550	765	762	171	225	Curled and soft.	Slightly checked.	Partly disintegrated.
2 weeks	548	767	771	170	246	Slightly curled.	Slightly curled..	Checked and cracked.
3 "	492	718	763	182	244	"O. K."	"O. K."	Slightly checked.
5 "	427	692	747	183	249	"O. K."	"O. K."	Sound.

TABLE II.—Effect of Fineness of Grinding on Results of Boiling Test.

Condition of cement.	Fineness. No. 50.	No. 100.	No. 200.	Boiling test.
As received....	0.5	13.2	33.4	Badly checked & cracked.
Same sifted....	0.0	0.0	0.0	Sound.
Same ground...	0.0	0.6	3.0	Checked and cracked.
Ground cement:				
1 week later..	0.0	0.6	3.0	Very slightly checked.
2 weeks later.	0.0	0.6	3.0	Sound.
As received:				
2 weeks later.	0.5	13.2	33.4	Checked and cracked.

TABLE III.—Comparison of the Tensile Strength of Briquettes Passing and Failing in the Boiling Test.

Age.	Failing in test. Neat.	Failing in test. 1:3 sand.	Passing test. Neat.	Passing test. 1:3 sand.
1 day	530	...	391	...
7 days	817	197	643	237
28 days	749	273	727	303
2 months	713	274	732	312
3 months	702	242	749	314



No. 1. Cement as received (tested 2 weeks later than No. 3). No. 2. Cement finely ground (tested same time as No. 3). No. 3. Cement as received (very coarse).

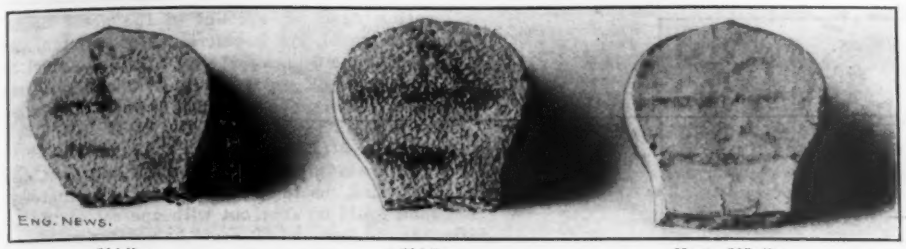
No. 4. Cement finely ground (tested one week later than No. 3). No. 5. Cement finely ground (tested 2 weeks later than No. 3). No. 6. Cement as received (sifted to pass No. 200 sieve).

FIG. 2. CAKES OF CEMENT OF DIFFERENT FINENESS AND VARYING AGE SUBJECTED TO BOILING TEST. (TABLE II.)

TABLE IV.—Evidences of Failure in Cement Indicated by the Boiling Tests.

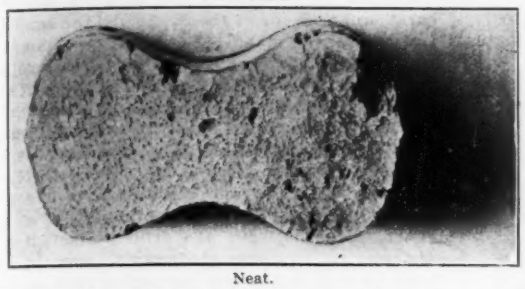
Tensile strength—Neat—1 day.	7 days.	28 dys.	4 months.	1:3 sand.—7 days.	28 days.	4 mos.	Normal pat tests.—Air—28 days.	Air—4 months	Water—28 days.	Water—4 months.	Boiling test.
522	793	797	Disintegratd	204	257	52	Very slightly curled; left glass.	Badly curled; soft and crumbly.	Left glass.	Disintegrated	Disintegrated.
503	872	586	"	184	239	47	Same as above	Same as above	" "	"	"
498	762	700	"	176	231	119	" " "	" " "	"O. K."	"	"
427	751	603	223	183	227	94	" " "	Disintegrated	" "	"	"
503	827	717	177	220	252	132	Left glass	Badly curled; soft and crumbly.	" "	"	"
492	883	620	202	195	217	147	Left glass	Same as above	" "	"	Badly checked.
535	864	743	94	197	241	77	Very slightly curled; left glass.	" " "	" "	Badly curled and checked.	Checked and cracked.
502	829	722	320	206	247	65	Same as above	" " "	" "	Same as above	Checked and cracked.
Neat tests not made.				172	219	93	" " "	" " "	" "	" " "	Checked.
Neat tests not made.				198	231	101	Left glass	" " "	" "	" " "	Checked.

Note.—All of these cements were normal in specific gravity at time of setting and fineness.



314 lbs. 314 lbs. Neat, 203 lbs.

1:3 sand.



Neat.

FIG. 4. NEAT BRIQUETTES CRACKING AND DISINTEGRATING, WHILE SAND BRIQUETTES OF SAME CEMENT REMAIN SOUND. (TABLE V.) PHOTOGRAPHED WHEN ONE YEAR OLD.

63% in 6 months, and 71% in one year. Or taking all these together, of all the samples that failed in the boiling test 86% of them gave evidence in less than a year's time of possessing some injurious quality.

On the other hand, of those cements passing the boiling test but ½ of 1% gave signs of failure in the normal pat tests, and but 13% showed a falling off in strength in a year's time.

This certainly makes a very strong showing in favor of the boiling test, at least considered from a laboratory standpoint.

In order to obtain some idea of the relative strengths obtained from cements that passed and that failed in the test, Table III. was compiled from 200 nearly consecutive tests of a single brand, 100 of them failing in the test, and 100 passing.

It will be noticed that the early strength of the neat tests of those samples failing to pass the test is much the greater, while the opposite is true of the sand samples. This table, while covering but a comparatively small number of tests, may however be considered fairly typical of the relations of the strength and the boiling tests, although of course exceptions may quite often be found.

In order to show the great value sometimes obtained from the results of the boiling test, several examples are given in Table IV. of tests of cements occurring in the regular routine work of the laboratory.

The first example is particularly remarkable in that at 28 days there was absolutely no sign of failure whatsoever except in the boiling test.

All of these samples were normal in specific gravity, fineness and time of setting, and both the tensile strength and the normal pats passed a good test at 7 days, the boiling test giving the only indication of an unquestionable failure occurring at a later period. It should also be stated that these are not exceptional or "freak" cases, but examples of a common, although not frequent occurrence.

Another point of considerable interest regarding the boiling test is this: The statement is frequently made that although a cement failing in this test may be otherwise sound, a cement passing the test may always be considered entirely safe, and although this is generally true it is by no means an invariable rule. It may often happen that a cement may pass the boiling test well, and yet check and disintegrate in the normal tests, particularly if the cement be slow setting, high in lime, and the test made soon after the specimen is molded. In these cases it seems that the boiling at first tends to hydrate the lime and render it inert, although it would be active under normal conditions. It is possible that sulphate of lime may act in this way in holding back the true setting of the cement, but giving it an artificial hardness due to its own hydration, thus giving it sufficient coherence to hold together in the test but allowing the boiling water to act on the lime before it has hardened, thus enabling it to hydrate without injury. It is thus frequently possible to add small quantities of lime to a sound cement and treat it in such a way that it will pass the boiling test perfectly and yet fail under normal conditions. The writer has recently seen the photograph of a test made in which as much as 15% of lime was added to a cement, and boiled, with excellent results, although the normal pats failed in a very short time.

Now finally, we come to what is after all the most vital question of all, and that is the relation of the results of the boiling test to the conditions found in actual work, and there every tester of cement runs against a stumbling block, for while almost everyone connected with testing can cite instances of failures in boiling being corroborated by failure in the work, it nevertheless cannot be denied that in the vast majority of cases work done with cement determined in the laboratory to be unsound will give most excellent results in practice and show not the remotest sign of any sort of failure.

This condition of affairs is due to two reasons, one of which can be readily explained, while the other is not so simple.

The reason that most cement shows such a radical difference in the results of the laboratory and of actual use is the fact that almost invariably the test is made considerably before the cement is used, a week almost always elapsing and often as much as a month, thus giving it plenty of time to season, and render the expansive elements ineffective. The shortest time customarily allowed, that of one week, being very often sufficient to make the difference between a radically unsound cement and one which is normal.

TABLE V.—Examples of Falling Off in the Strength of Neat Briquettes, Without Similar Action Shown in the Sand Briquettes.

Neat					1:3 sand.			
Days.			4	1	Days.		4	1
1.	7.	28.	mos.	year.	7.	28.	mos.	year.
450	782	705	392	203	180	252	309	314
493	717	801	317	241	172	247	283	297
429	685	793	593	318	200	251	298	323
473	791	790	502	291	192	267	287	301
502	823	752	421	200	184	229	252	251
423	802	741	511	277	212	237	290	303
479	784	782	520	321	202	238	301	318
461	791	797	493	290	178	251	277	276

The second reason is that the disintegrating action of a cement is always far greater when mixed neat than when mixed with an aggregate, and the greater the amount of the aggregate the less the tendency to unsoundness. This can often be observed in the laboratory tests, cements often completely disintegrating in the neat briquettes, but retaining their strength in the sand tests.

Table V. shows a few instances of this sort.

In conclusion, it can be stated that although in the great majority of cases the results of the boiling tests can be considered as being indicative of the future behavior of the cement from a laboratory standpoint, one cannot be too careful in condemning cements on this test alone unless his experience has covered a large number of tests and many varieties of material, and even then it is questionable if the rejection of cements on the results of this test alone is justifiable. It is often policy to hold a cement for a week or two so that it may have an additional amount of seasoning, but to reject a cement outright will usually only result in much annoyance to both engineer and contractor without anything being gained.

It is much to be regretted that, in spite of the great importance and extended use of the accelerated tests of cement, so little work of value has been done on their investigation, and it is believed that this Society could do nothing of greater importance to the cement trade than to inaugurate a systematized investigation of the subject, in the hope of clearing up some of the many unexplained phenomena connected with it, and of devising some form of this test in which the results are not open to so much question.

AUXILIARY DRAINAGE CANALS are to be built by the Sanitary District of Chicago, to carry the sewage of Evanston on the north and the Calumet district on the south into the main drainage canal, and to prevent it from polluting the lake, as at present. Surveys are to be made at once, and there will probably be two channels from Evanston to the north branch of the Chicago River, while the Calumet channel will run direct to the drainage canal at the Sag.

EXPERIENCE IN DIAMOND DRILL WORK ON THE DEEP WATERWAYS SURVEY, WITH STATISTICS OF COST.

In Part II. of the Report of the Board of Engineers on Deep Waterways between the Great Lakes and the Atlantic (1900) there are to be found some excellent and reliable data of costs of drilling 25 holes each averaging about 100 ft. deep.

The work was done by the day between Oct. 1, 1898, and May 12, 1899. The holes were far apart so that frequent and long moves were necessary. Moreover the work was done in the winter when the roads were at times almost impassable. Thirty-three moves were made by trains covering 110 miles, 75 miles being over bad roads. Five moves, aggregating 500 miles, were made by rail, and there was much delay waiting for cars.

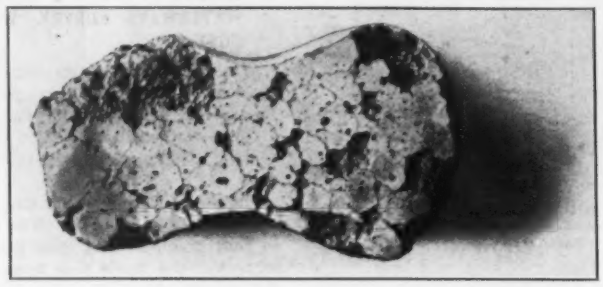
The plant consisted of an S-drill made by the Sullivan Machinery Co. of Chicago. This drill was mounted on wheels and had a capacity of 500 ft., and the core barrel was 10 ft. long. A 15-HP. boiler, a Blake steam pump, a derrick and shanty, together with rods, bits, carbons, etc., completed the outfit. This plant was rented for $300 a month, wear of bits and carbons being paid for extra by the Government. Carbons were paid for at $36.50 per carat, and all stones worn or broken so as to weigh less than one carat were counted as worn out. A 15-16-in. core was secured in the harder rocks, but in shales or softer rock a 13-16-in. core was drilled out. Carbons averaged 2 carats each.

The party consisted of a superintendent, a foreman, two laborers, a night watchman, and a team with driver employed at rates of wages given in the tables following. It will be observed that this was an expensive party. The working day was 10 hours long, six days a week. Aside from delays of moving, very little time was lost from bad weather. The column of delays includes all time not spent in actual drilling or moving. The amounts in all columns are a little large since ½ to 1 hour each day was lost on account of the early darkness in winter time which prevented working a full 10-hour day.

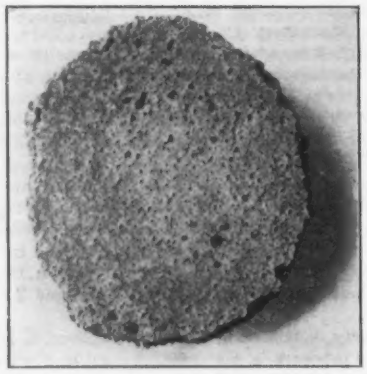
DIFFICULTIES AND DELAYS ENCOUNTERED.

Hole No. 1, Tonawanda-Olcott Route: Only 25% of the ledge core was saved, clay between rock layers grinding up and washing away. Hole No. 2, T.-O. Route: It required 2½ days to get the casing down to the ledge on account of boulders encountered. Hole No. 3, T.-O. Route: The drill had to be heavily weighted to force the bit into the sandstone which polished the carbons badly; and at a depth of 7½ ft. the flow from the pump was lost through a crevice in the ledge, so it became necessary to ream the hole and sink the casing below the crevice—a costly operation as two carbons were broken causing a loss of 2½ carats. Hole No. 5, T.-O. Route: Limestone broke up badly causing core barrel to jam, necessitating frequent pulling up and removal of core; trouble also occurred at the start in seating the casing as the ledge dipped so that a casing bit set with carbon fragments had to be drilled into the rock a few inches to get a good seating. Hole No. 7, T.-O. Route: On attempting to pull up the core barrel and rods from a depth of 70 ft., it was found that loose material had caved in above the core barrel which is larger than the rods, so that after raising about 3 ft. the core barrel wedged; and it was found necessary to ream the rock down as far as the core barrel before it could be loosened; then the casing was churned down until it reached the top of the core barrel, but when the jacks were applied, the rods raised a few inches and broke about 30 ft. below the surface, when it became necessary to ream the rock clear to the bit before the core barrel was loosened sufficiently to be raised with a recovering tap. In moving from this hole to the next, nearly all one day was consumed due to deep snow drifts; and another difficult move of like nature occurred at the hole following.

This finished the Tonawanda-Olcott (T.-O.) Route; and in moving to the Lasalle-Lewiston Route (L.-L.) three days were lost waiting for a



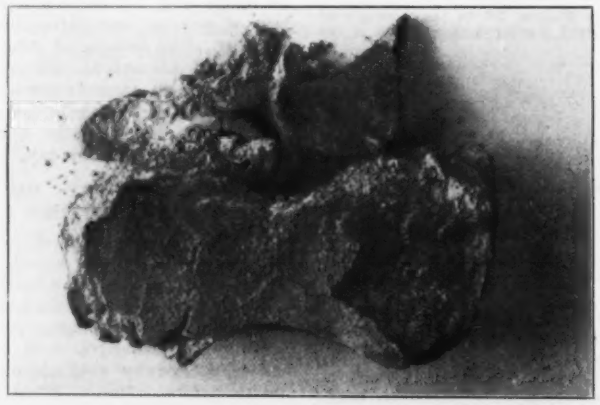
Briquette kept in water.



Normal air pat.

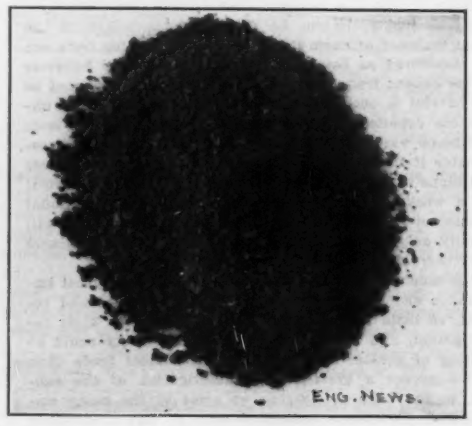
Normal water pat.

Failed in boiling test, but sound in every other test up to 28 days. Photographed at four months.



Briquette kept in water.

Normal water pat.



Normal air pat.

At the age of 28 days all these specimens were perfectly sound, and every test made within that period gave normal results, with the exception of the boiling test, where the cement failed.

FIG. 3. EXAMPLES OF UNSOUNDNESS DEVELOPED BY BOILING TEST. (TABLE IV.)

car, although one had been ordered three days in advance.

Hole No. 4, L.-L. Route, proved to be very costly drilling, 4 carats of carbons being broken below the "1-carat limit;" and on attempting to pull the 3-in. casing, the pipe broke at a coupling so that the "drive shoe" and 35 ft. of pipe were lost.

Hole No. 1, Oswego-Mohawk Route, at Oswego, N. Y., was the first to be delayed by storm; for, on account of freezing, water could not be gotten to the hole, and 1½ days were lost. Hole No. 2, O.-M. Route: The move from Hole No. 1 required a whole day due to snowdrifts; and after setting up, great difficulty was experienced in getting the casing down on account of the great depth of sand, gravel, and boulders passed through. After sinking the 3-in. stand-pipe 21 ft., the steel drive shoe broke off necessitating pulling up and starting a new hole, one day being partly lost waiting for a new shoe; at a depth of 45 ft. in the second hole the stand-pipe again stuck, so rather than risk breaking it by heavy driving, the 2-in. casing was sunk inside it to the ledge; fortunately the sand could be shut out with one set of casing so that the diamond bit could be put down. Hole No. 5, O.-M. Route: The shale encountered contained numerous hard seams in one of which about ½ carat broke off one of the diamonds; the sand settled around the stand-pipe so that on attempting to pull it up it broke leaving 19 ft. of pipe and drive shoe in the hole. Hole No. 6, O.-M. Route: In "churning" into the broken slaty material a chopping bit was broken at 36 ft. making it necessary to pull up and start anew; one day was lost also on account of stormy weather. Hole No. 7, O.M. Route: Gravel and boulders were encountered and gave trouble; after sinking to what appeared to be the ledge and drilling about 8 ins., clay was encountered, so dynamite was used to break up the boulder and the casing sunk past it.

Hole No. 1, Champlain Route: The carbons polished so badly on the quartzite that two bits were used in drilling 36 ft. Hole No. 3, C. Route: Like hole No. 1, 5 bits used in drilling 108 ft.; the loss by carbon breakage was one carat; and two days were lost waiting for blank bits and repairs from Chicago.

The following table gives the carbon losses:

Carbon Losses in Diamond Drilling.

Carats—Wear.	Carats—Breakages.	Feet drilled—Limestone.	Feet drilled—Shale.	Feet drilled—Sandstone.	Feet drilled—Quartzite.	Feet drilled per core bit.
3 19/64	3	....137.8	106.9	30.0	.....	91.6
1 21/64	½	.... 90.9	164.7	65.0	.....	161.3
41/64	...	.... 82.4	309.2	....	.....	391.6
5 58/64	4	.... 53.4	240.8	67.1	.....	150.3
22/64	...	....	29.7	114.2	.....	71.9
1 2/64	½	.... 49.8	28.8	87.1	.....	165.7
2 50/64	...	.... 30.1	....	....	151.7	26.0
52/64	1	....	....	....	70.0	75.0
16 5/64	9	....444.4	880.1	363.4	221.7	....

The above losses are for each month, each horizontal line being a full month, except the last in which the wear was 52-64 carats which was for 12 days only. The total carbon loss was 25 6-64 carats in drilling 1,688 ft. of rock, or 0.001307 carat per ft. which at $36.50 per carat made the cost for diamonds 47.7 cts. per ft. The average life per diamond of 2,135 carats was 163.5 ft. or 76.5 ft. per carat.

A blank core bit costs $1.25.

ANALYSIS OF THE TABLES OF COST.

An analysis of the accompanying tables leads to some interesting conclusions. We note first that while actually at work, the rate of progress in sinking the casing through sand, gravel, etc., was 1.7 ft. per hour, as compared with 2.53 ft. per hour drilled in rock. The three holes in which the most rapid stand-pipe sinking was done were: No.

Cost per Foot of Diamond Drilling on Deep-Waterways Survey.

Routes: L.-L. and T.-O.—Lasalle-Lewiston and Tonawanda-Olcott; O.-M.—Oswego-Mohawk (Western Division); C. R.—Champlain Route (Northern Division).

	L.-L. & T.-O. route, (1.)	O.-M. route, (2.)	C. route, (3.)	Total average, (4.)
Rental, plant, $300 per mo.	$0.769	$1.150	$1.099	$0.896
Carbons, $36.50 per carat..	.423	.139	.490	.372
Labor*	.542	1.016	1.024	.714
Team, $75 to $90 per mo...	.124	.345	.368	.245
Team, extra	.077	.177	.190	.109
Supt. at $125 per mo.....	.321	.479	.547	.390
Repairs	.042	.101	.072	.052
Coal.†	.039	.066	.073	.050
Lumber for shanty.....	....	....	....	.023
Core boxes	.015	.010	.020	.014
Freight and express.....	.042	.143	.225	.135
Towel expenses	.042	.058	.201	.083
Sundries	.058	.054	.057	.033
Total, per foot.....	$2.494	$3.738	$4.366	$3.137
Feet of rock	1,378	280	252	1,910
Feet of earth.....	219	242	91	552
Total No. feet.....	1,597	522	343	2,462
Ft. of rock per carat.....	.....	.....	.....	76.5
Lbs. coal per ft. of hole...	28	43	.....	.....
Average depth of hole.....	.....	.....	.....	98.5

*Two laborers and 1 night watchman at $55 per month (10 hr. day), and 1 driller at $100 per month.

†44,700 lbs. soft coal at $2.83 per ton for column (1); 22,400 lbs. soft coal at $3.06 per ton for column (2); 2,400 lbs. soft coal at $4.75 per ton and 6 cords hard wood at $3.25 for column (3).

Time of Drilling Holes on Deep Waterways Survey.

Route.	No. of hole.	Depth in ft. in earth.	Depth in ft. in rock.	Depth in ft. Total.	Kind of rock.	Sinking stand-pipe in earth.	Hours. Drilling rock.	Hours. Delays.	Hours. Moving.	Hours. Total.
Tonawanda-Olcott	1	33.3	15.8	49.1	Limestone	5	9	15	6	35
" "	2	24.7	89.3	114.0	Lime conglomerate	20	30	19	6	70
" "	3	1.8	199.1	200.9	L., shale, sandstone	3	90	30	7	135
" "	4	6.0	52.6	58.6	Limestone & shale	3	16	12	4	35
" "	5	11.5	46.5	58.0	Limestone	7	15	7	6	35
" "	6	1.4	192.9	194.3	L., shale, sandstone	5	88	22	5	120
" "	7	13.7	86.2	99.9	Shale	13	36	26	5	70
" "	8	13.5	166.8	180.3	"	6	36	8	10	60
" "	9	12.5	55.3	67.8	"	5	11	4	10	30
Total		118.4	904.5	1,022.9		67	331	143	59	630
Lasalle-Lewiston	1	23.0	26.3	49.3	Limestone	5	12	5	53	75
" "	2	12.6	56.1	68.7	Limestone	6	23	11	5	45
" "	3	9.6	209.4	219.0	L., shale, sandstone	10	82	36	12	140
" "	4	46.7	58.3	105.0	Sandstone & shale	32	26	26	6	90
" "	5	9.1	123.3	132.4	Shale	4	24	8	4	50
Total		101.0	473.4	574.4		57	167	86	80	400
Oswego-Mohawk	1	12.8	92.3	105.1	Sandstone	5	42	22	26	95
" "	2	77.4	21.9	99.3	"	80	11	34	15	140
" "	3	12.4	18.9	31.3	"	5	8	7	5	25
" "	4	18.4	68.2	86.6	"	8	23	13	6	50
" "	5	24.0	28.8	52.8	Shale	3	7	4	6	20
" "	6	37.0	38.0	75.0	Slate and limestone	30	15	29	26	100
" "	7	59.7	11.8	71.5	Limestone	58	5	9	8	80
Total		241.7	279.9	521.6		189	111	118	92	510
Champlain	1	35.2	36.2	71.4	Quartzite	3	22	10	45	80
"	2	7.6	77.5	85.1	"	4	40	6	20	70
"	3	0.0	108.0	108.0	"	0	64	21	25	110
"	4	47.9	30.1	78.0	"	5	18	22	35	80
Total		90.7	251.8	342.5		12	144	39	125	340

1, T.-O. Route, 33.3 ft. in 5 hours, or 6.6 ft. per hour; No. 1, L.-L. Route, 23 ft. in 5 hours, or 4.6 ft. per hour; No. 5, O.-M. Route, 24 ft. in 3 hours, or 8 ft. per hour; No. 1, C. Route, 35.2 ft. in 3 hours, or 11.7 ft. per hour; and No. 4 C. Route, 47.9 ft. in 5 hours, or 9.6 ft. per hour. We thus see that there is a big range from the average of 1.7 ft. per hour. The very deep holes Nos. 2 and 7 of the O.-M. Route, on the contrary, required about an hour for each foot of stand-pipe or casing sunk. Then there are a few holes, like No. 6, T.-O. Route, where 5 hours was consumed in sinking a stand-pipe 1.4 ft. deep which is anomalous and unexplainable unless the time consumed in setting up and getting ready to begin work is charged against "sinking stand-pipe," which we are inclined to think must have been the case, for it is stated that the "time of moving is counted from the time the machine was ready to move from a hole until it reached the location of the next hole."

A study of the tables shows the average time consumed while actually drilling in rock as follows:

Kind of rock.	Ft. drilled per hr.	Kind of rock.	Ft. drilled per hr.
Quartzite	1.7	Sandstone	3.0
Limestone	2.5	Shale	5.0

Of course as holes become deeper the time consumed in raising the rods to remove cores increases, and the feet of hole drilled in a given number of hours is correspondingly reduced; but as the holes were approximately the same depth, the relative hardness of the rocks penetrated is well indicated by the foregoing tabulation.

Passing now to the proportion of time spent in sinking casing, drilling rock, delays and moving, we observe that while the totals in the last column give 1,880 hours consumed in all, that an actual summation shows only 1,820 hours. The discrepancy is probably due to omission to include holidays and stormy days in the column of delays. Summarizing, we have:

Sinking casing	325 hrs.	17%
Drilling rock	753 "	41%
Delays	386 "	20%
Moving (38 moves)	356 "	19%
Holidays and storms	60 "	3%
Total	1,800 hrs.	100%

As before noted the item of moving was unusually high due not only to frequent and long moves but to delays from bad weather and delays in getting cars.

The number of feet of stand-pipe sunk was 552 ft., the number of feet of rock drilled was 1,910, making a total of 2,462 of hole which divided by the number of 10-hr. working days (188) shows an average of 13.1 ft. sunk per day including delays and moving. Not counting the time of moving, the progress in sinking was 16.2 ft. per day. While actually working the rate of sinking the casing through earth was 17.0 ft. per 10-hr. day, and in rock 25.3 ft. per 10-hr. day. As above stated the slower speed in sinking the casing appears to have been largely due to the fact that the time of setting up the plant was charged to the time of sinking casing.

Since this is the most reliable data of the cost of diamond drilling shallow holes of which we have any record it has seemed advisable to give it in detail.

A NOVEL ELECTRIC MINE LOCOMOTIVE.*

By W. B. Clarke,† Mem. Am. Inst. M. E.

Electric mine-locomotives are very extensively employed for the haulage of coal on the main entries and the branch-headings; but in the majority of coal mines the cars are still "gathered" from the breasts by mules or horses. In a few low-vein mines, where very small cars are necessarily used, the miners push the cars between the working-faces and the "room-necks," from which points they are collected by locomotives and hauled in trains to the tipple or shaft-bottom. This practice is very limited, and is confined to practically level rooms. Mine-haulage, with mules or horses, is very expensive and extremely unsatisfactory, especially where large cars are used, or where the rooms are driven on even moderate grades. It would be decidedly advantageous in many mines to employ larger and fewer cars or to have heavier grades in the rooms, provided a suitable substitute for the mule were available. The use of larger cars, handled expeditiously, would materially increase the output of a mine, with the same amount of development. In many veins it is necessary to increase the height along all of the haulage-rooms in order to accommodate the smallest animals obtainable. The cost of "brushing" the roof, or taking up the "bottom," is a formidable expenditure, especially since the material encountered is usually a hard slate or limestone. This would be eliminated in many cases by the adoption of electric mine-locomotives. It is evident from the above remarks, that an efficient gathering-locomotive would meet a very important requirement in mine-operation. For service of this nature, compressed-air and electric storage-battery locomotives have been used to some extent. The compressed-air locomotive is not an unqualified success for the following reasons:

(1) The radius of operation is restricted. The locomotive must necessarily be very compact, and consequently has small storage-capacity, so that the reservoirs require frequent recharging.

(2) The efficiency of the compresed-air locomotive is very low, usually less than 40%, while the plant-efficiency, i. e., the ratio between the effective work performed by the locomotive and the indicated horse-power of the steam-cylinders of the air-compressor, seldom exceeds 20%. In comparison with these figures, the plant-efficiency of an electric mine-haulage system, considering the losses in the engine, generator, line and locomotive, is ordinarily about 55%.

(3) Finally, the compressed-air plant costs from two to three times as much as an equivalent electric mine-haulage system. From the lower efficiency, it follows that the boiler-plant must be much larger, while the compressed-air locomotive itself costs much more than an electric locomotive. A three or four-stage air-compressor is an expensive piece of apparatus; and the heavy pipe-line, incident to the high pressure, is very costly indeed. In this connection, it might be well to add that the maintenance of the compressed-air plant, as compared with the electric system, is exceedingly high. Compressed-air locomotives are relatively complicated, and are subject to very frequent repairs, with consequent interruption in the output of the mine.

Electric locomotives, equipped with storage-batteries, have been tried for this class of service, and have also proved unsuccessful. At first thought, it might seem very simple to provide the locomotive with a storage-battery of such a voltage that the batteries would receive their charge whenever the locomotive operates from the trolley in the ordinary manner. Since the locomotive would operate from the trolley-wire on the main entries and branch headings during at least two-thirds of the time, it might be assumed that the batteries would always be fully charged. In practical operation, however, it is found that the voltage at the locomotive varies continually between very wide limits (on account of the line-drop); and when it falls below the potential of the batteries, they very promptly discharge into the line and assist the generating station. The practical result follows that it is impossible to keep the batteries charged in this manner, except by maintaining a perfectly uniform voltage throughout the entire system, which would entail an enormous and prohibitive investment for line-feeders. A complicated ar-

MINING LOCOMOTIVE FITTED WITH AUTOMA TIC CABLE-REEL.
General Electric Co., Schenectady, N. Y.

rangement of voltmeters, ammeters and switches might be employed; but the fact remains that the motorman has but two hands, and they are engaged with the ordinary operating device. Again, it would be possible to regularly charge the batteries from a separate plant, installed especially for that purpose. But, if the locomotive were in continual service (and that is presumably the purpose for which it is intended), the limitations of size and weight would necessitate several sets of batteries. In either case, the batteries are expensive, and the cost of maintenance and depreciation for this severe service would be from 60 to 100% per year. The batteries must necessarily be

*Condensed from a paper on "Electrical Apparatus for Coal Mining" read at the Albany meeting of the American Institute of Mining Engineers, February, 1903.

†Electrical Engineer, General Electric Co., Schenectady, N. Y.

placed on the top of the locomotive, where they prevent ready access to the motors; and, in actual service, no little trouble has been experienced by the spilling of the acid solution. Furthermore, the fumes from the cells render the occupation of the operator disagreeable in the extreme.

To meet the demand for a gathering-locomotive, the engineers of the General Electric Co. have designed a "cable-reel device," (see view*) which may be applied to standard electric mine-locomotives. This device is, briefly, a vertical reel of relatively large diameter, containing a flexible insulated cable. The end of the cable is connected to the trolley-circuit and the current is conducted to the controller on the locomotive through a suitable contact at the center of the reel. Iron rails are now quite generally used for room-haulage, in place of wooden rails; and a single conductor-cable with rail-return would ordinarily be employed.

The reel is driven by means of a sprocket-chain and bevel-gearing, connected with one of the axles of the locomotive. The gearing consists of a small pinion on an intermediate shaft and a large horizontal gear. The reel proper is not rigidly attached to the horizontal gear, but is driven therefrom by the friction due to its weight. The horizontal intermediate shaft, driven by the sprocket-chain from the main axle, is in motion whenever the locomotive is running, and carries two miter-pinions which are stationary, except when the reel is in use. Each of these pinions, within which the intermediate shaft ordinarily revolves freely, is provided with a clutch, operated by a lever located conveniently near the motorman. These clutches are automatic to the extent that they will positively operate the pinions in but one direction. At the entrance to a room, for instance, the trolley-pole is fastened down; the cable is connected to the trolley-circuit; and one of the clutches is thrown in by moving the lever to one side from the central "off" position. As the locomotive proceeds towards the face of the room, the cable unwinds from the reel, and the friction of the various parts is sufficient to preserve a tension on the cable of about 30 lbs., which effectually prevents "kinking."

The instant the locomotive starts in the opposite direction (toward the heading), the pinion is positively driven from the intermediate shaft by means of the automatic clutch. A motion is consequently transmitted to the reel and the process of rewinding the cable begins. The direction of the locomotive is reversed in the room without any manipulation of the clutch-lever, which was adjusted before leaving the heading. If the room branches off from the heading in the opposite direction, the other pinion and its clutch are employed; the two pinions being designed for opposite directions of positive rotation. In other words, the operations of reeling and unreeling the cable are independent of the direction in which the locomotive is moving.

As stated before, a tension of approximately 30 lbs. is maintained on the cable while unreeling. The essential feature of this device is the method by which the same result is accomplished while reeling on the cable. If the reel were positively driven, it would not wind the cable on with sufficient rapidity at first, and the locomotive would be liable to run over and cut the cable. Assuming that this did not occur, as the diameter of the reel increases by the additional layers of the cable, the speed at which the cable is taken would be too high, and the cable would be broken. As already stated, the connection between the reel proper and the driving-gear is due entirely to the friction between large annular surfaces. The ratio of the driving-gearing is such that, except for the friction-surfaces, the peripheral speed of the reel would be about 25% higher than the linear speed of the locomotive. It is obvious, therefore, that when the cable is being wound on to the reel there is always a slipping between the friction-surfaces, with the result that the same tension of 30 lbs. is maintained on the cable at all times. This is the essential feature of the whole mechanism, since it is practically impossible to run over or part the cable, and there is always sufficient tension to prevent "kinking." The automatic pinions are also of prime importance, for by means of these no manual adjustment of the clutches is necessary while the locomotive is operating in a room. The impossibility of damaging the cable was demonstrated in experimental tests by reversing the locomotive repeatedly at full speed.

*We have substituted for the line drawing accompanying the paper a reproduction of a photograph supplied at our request by the General Electric Co.

SEMI-ANNUAL MEETING OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The sixth semi-annual meeting of this society was held at the Cataract House, Niagara Falls, N. Y., on July 17 and 18. Over forty members and invited guests were registered as in attendance, which is a large number for the summer meeting of a national technical society whose total membership is only about 200.

The first session was held on Friday afternoon, July 17, with President H. D. Crane in the chair. After a brief address by the president and a statement by the secretary, showing that the society was rapidly increasing in membership and influence, the presentation of papers was begun. The first paper, by Mr. J. Gormly, appears in abstract immediately below:

DESCRIPTION OF A LOW-PRESSURE STEAM-HEATING SYSTEM WHICH PROVED DEFECTIVE IN OPERATION.

By John Gormly, Philadelphia, Pa.

The building in which the plant is installed is used for general stores on the first story, and for offices on the other stories. It has a central section one story in height, one wing three stories in height and another wing four stories in height. The boiler is located under the one-story portion.

A basement story extends under the entire building; in this basement are located two steam circuits or main pipes supplying respectively the three-story and four-story wings. From each circuit branch connections run to the various vertical pipe risers. These connections fall toward the steam main and rise toward the vertical risers.

The building is of modern construction of brick with fireproof inner partitions. It contains about 96,000 cu. ft. of space, 11,000 sq. ft. of exposed wall surface and 1,000 sq. ft. of glass surface.

The entire plant contains 1,370 sq. ft. of direct cast-iron steam radiation. The mains and branches are not covered by non-conducting material. The boiler used has a grate 27 × 54 ins., or 10½ sq. ft. of grate surface; 198 sq. ft. of heating surface; height of water line from floor, 57 ins.; top of steam drum from floor line, 80 ins. The boiler is vertical, cast-iron, sectional, rated at 1,775 sq. ft. direct steam radiation.

The steam-supply mains rise at the boiler and descend as they recede from that point. The grade is 1 in. in 17 ft.

Each radiator is connected by one pipe to the steam mains and risers.

An automatic air-valve is located on each radiator two-thirds of the distance from the floor to the top of the radiator, on the opposite side of the radiator to that on which steam is admitted.

The boiler is located in the basement, 30 ft. from one end of the building and 70 ft. from the other end of the building. A 2½-in. main supplies the three-story portion of the building from which are taken two 2-in. risers and one 1½-in. riser. A 2-in. return pipe takes condensation back to the boiler from this end of the building. The main steam supply pipe runs 48 ins. above the water line of the boiler, at its lowest point in the three-story end of the building. At its farthest point from the boiler, it returns above the water line as a dry circuit until it reaches the boiler, where it then connects to one header of the boiler below the water line. It might be classed as a dry circuit sealed at the boiler end of its return connection. This portion works very well and has given no trouble. This 2½-in. main carries 270 sq. ft. direct radiation.

The other circuit, to the 70-ft. run in the four-story end of the building, rises high at the boiler and gradually descends at a grade of 1 in. to 17 ft., where it is relieved of condensation through a 2-in. relief pipe, which is enlarged to 3 ins. at a point 50 ft. from the boiler. This circuit is carrying 1,100 sq. ft. direct radiation. It leaves the boiler and is carried 4-in. in size, a distance of 70 ft. to a right angle ell, thence 25 ft. across the end of the building farthest from the boiler where it reduces to 3½-in. for a distance of 40 ft. and is then reduced to 3-in. to the boiler. It runs above the water line until it drops at the boiler where it is joined below the water line to a header attached to the opposite side of the boiler. There are five 2-in. risers atached to this dry circuit of pipe; these risers have spring pieces about 2½ to 3 ft. in length connecting the risers to the main steam supply pipe. The grade of the connecting pipe is upward from the steam main pipe to the base of the vertical risers; there are no relief pipes to carry condensation away from the bottom of the vertical steam risers. The risers are taken from the main pipe at the following distances: from the steam boiler, 18 ft., 30 ft., 40 ft., 60 ft. and 100 ft. There are four 1½-in. connections on this circuit, which supplies four radiators on the first story, two of these are at the extreme end, 70 ft. from the boiler, two are about central between the boiler and the end of the building.

When the plant was tested it is reported to have worked perfectly at 1 lb. pressure, heating all radiation well, but at 2 lbs. gage pressure, all water would leave the water glass. If the fire doors were opened, the water would instantly return to its proper level; this effect could be produced each time it was tried.

As an experiment, a 2-in. branch steam connection was placed in the return end of this loop of pipe, in other words the steam drum of the boiler and the nearest point on the return pipes were so connected that the steam was admitted at boiler pressure to the farthest point on the return pipe. This was intended to break any vacuum in the circuit and thus prevent water from the boiler rising into the return pipe and filling the circuit of pipes. The result was disappointing, water was lost in the water gage just as before.

The boiler expert now had the return pipe disconnected close to the boiler above the water line; this was done on three occasions and never caused more than three gallons of water to appear at the point where disconnected. There were valves and flange unions on the mains near the boiler. They could thus be opened readily. Several experts were now called in. It was suggested to cut the main return at a distance of 65 ft. from the boiler and drop the main return below the water line from that point to its junction with the boiler. This was done but the results were not satisfactory. The water still leaves the gage glass, the plant burns an unusual amount of coal; in moderate weather a ton of anthracite coal lasts six days; in cold weather it lasts three days. The party who installed the plant makes the following replies to questions asked:

Used check valves on the return as an experiment, but as they did no good they were discarded.

Draft was too strong in flue, had to close damper in flue about one-quarter of its area; flue was 12 × 16 ins., 60 ft. high, brick construction, with good draft.

No water showed at air valves.

Anthracite coal, stove size, was used.

Angle valves were used at radiators to control steam supply.

Radiators were three-column vertical sectional and wall pattern.

All one pipe work.

Air valves were on the opposite end of each radiator from point of steam admission.

The water column on the boiler had connection from the steam drum and from the bottom of the boiler section.

The plant now runs up to 6 lbs. gage pressure before water will leave the glass. This advance in pressure was caused by placing a section of the return pipe below the water line of the boiler and thus making that portion a wet return.

When the plant was installed it was discovered that by shutting the pipe circuit which supplies the three-story wing of the building, the four-story end being in operation, it was possible to run the plant to 3 lbs. gage pressure before losing the water from the water glass, but on opening the circuit to supply the three-story wing, 1 lb. gage pressure was all that could be carried without loss of water from the glass.

Pressure to the extent of 3 lbs. by the gage is maintained on the plant night and day continuously, while the plant is in use. If the gage pressure is reduced below 3 lbs., the water rises in the gage glass and floods the steam space of the boiler. The party that installed the plant thinks the trouble lies chiefly in the over-rating of the boiler, as the same size boiler in 1898 was rated at 1,400 sq. ft., in 1900 it was rated at 1,600 sq. ft., and in 1902 it was rated at 1,750 sq. ft.

Many of the boiler manufacturers have raised the ratings of their boilers to such an extent in recent years that a conservative engineer will not place these boilers at their present ratings or within two sizes of their ratings, if he desires efficient service from the plant which he installs.

An extended discussion followed the reading of the paper. Many of the members confessed to having had similar difficulties, and a satisfactory theory of their occurrence does not seem to have been made public. These small steam heating plants seem to have a habit of violating the common law that water will not run up hill, just as the steam loop seems to violate it.

The discussion of "Topical Questions" was then taken up. These were:

(1.) What is the proper method of rating steam and hot water boilers for heating purposes?

(2.) The relation of space between sections to the efficiency of steam and hot water radiators.

(3.) The advantages and disadvantages in the use of wrought or sheet iron for steam and hot water radiators.

The second session was held on Friday evening. The first business was the report of the Committee on the Tenth Anniversary Meeting, which is to be held in January next. The committee announced that it had arranged to have papers presented by eminent specialists in each branch of the heating and ventilating art, with a view to placing on record a description of the best American practice in each branch, including hot air, water, and steam heating, forced and induced ventilation, heating of schools, ships, etc., and refrigerating. A report was made by the Board of Governors concerning the question that had been submitted to it at the annual meeting in relation to the advisability of forming chapters of the society in different sections of the country. The report was adverse, and the discussion that followed showed that most of the members agreed with the board. It was stated that members of the society in different cities might form sections of their local engineers' clubs or societies and

present papers therein on heating and ventilating, and if they were of sufficient merit or importance they might then be discussed by the national society.

Topical discussions on the following questions were then held:

(1.) The relative dimensions, weight and material in piping systems under a steam pressure of 200 lbs. or over, in pipes, fittings, flanges, gaskets, etc.

(2.) Is there any reliable short rule for approximating the cost of pipe and fittings per 100 ft. of surface of heating system, including the cost of labor?

The concluding session was held on Saturday morning. A paper was presented by Geo. M. Aylesworth, M. D., of Collingwood, Canada, on "The Scientific Basis and Commercial Feasibility of Heat Radiators Using Air Instead of Water or Steam."

The paper described a radiator made of thin sheet-metal, with long flat air passages of a constant cross-section equal to that of the supply-pipe. The radiator is so divided that the external air can flow freely upward past the heated surfaces and thereby warm all the air in the room. Two experiences with this form of radiator in heating dwelling houses were recounted. In both cases an old hot-air furnace was employed, the return pipes from the radiators being led back to the supply opening of the air space in the furnace. The results were quite satisfactory as to efficient and uniform heating; the coal consumption was thought to have been at least no greater than with the previous unsatisfactory hot-air installation.

The paper caused a great deal of discussion, and much interest was manifested in the new system of house heating described. A sample four-section radiator was shown. Each section had 14 sq. ft. of radiating surface. Further data on the operation of the system are promised for the annual meeting next January.

The remainder of the session was occupied in the discussion of the following topics:

(1.) The effect of humidity on the load or work of a heating system.

(2.) The relative importance of grate and heating surface in proportion to exposed surface in furnace-heated buildings.

(3.) The relative value of fire-pot and other surfaces in hot-air furnaces.

In the afternoon the members and their guests had an excursion in a special trolley car over the Niagara Gorge Railway to Lewiston and return.

PORTABLE PNEUMATIC REVOLVING CRANES.

There is a wide field of use for portable power cranes in railway yards, manufacturing plants, etc., where neither overhead traveling cranes nor fixed cranes will meet the requirements. A special form of power crane which is now coming into use for a variety of purposes is a portable pneumatic crane mounted on a truck with flat or flanged wheels, and having a turntable by which the boom can be swung horizontal through a complete circle. Fig. 1 shows the general design and construction of these cranes, but in this case there is the special feature of a pivoted boom, although most of the machines have a fixed boom.

Upon the car or truck is mounted a turntable, the lower (fixed) part of which contains the cylinder, rack, guides, pivot and stop, while around its edge is a machined race for a series of 193 steel balls which form the bearing for the upper (revolving) portion of the turntable.

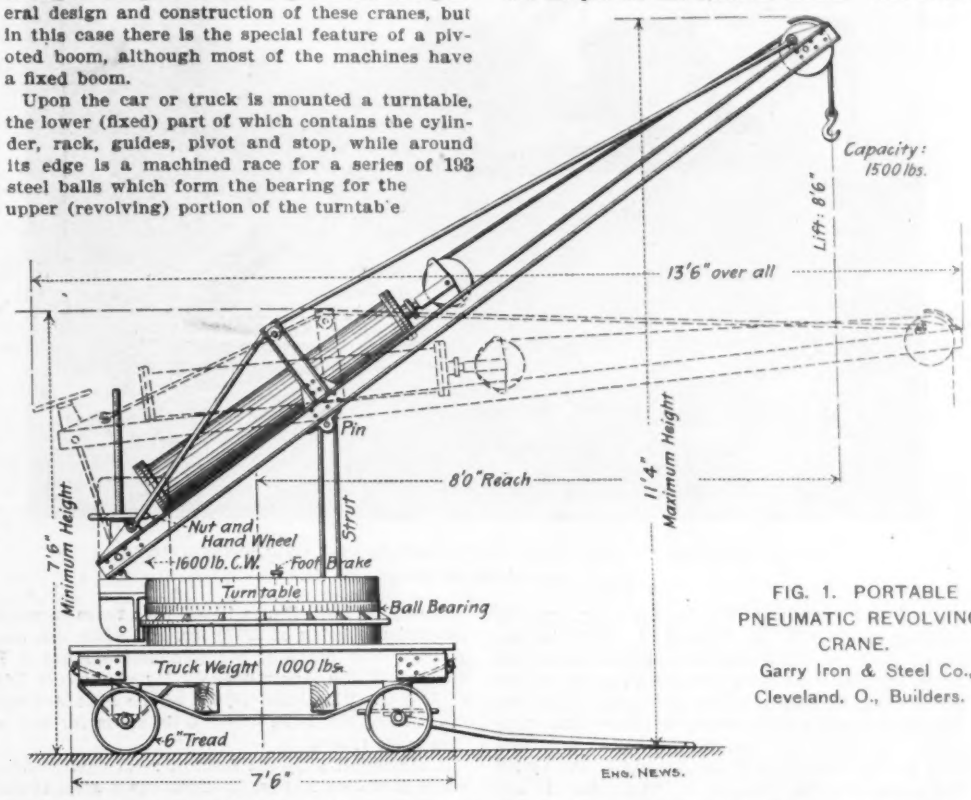


FIG. 1. PORTABLE PNEUMATIC REVOLVING CRANE.
Garry Iron & Steel Co., Cleveland, O., Builders.

The lower part of a turntable is shown in Fig. 2, and beyond it is a crane assembled, with inclined hoisting cylinder in position. The two horizontal cylinders are the racking cylinders for rotating the machine.

The platform of the turntable has a machined race engaging with the steel balls, and is secured to the base by a bracket under the rear end of the cylinder, shown in Fig. 2. Attached to this bracket, and revolving on brass bushings, are two faced wheels running on the under side of the rim or flange of the fixed base. These wheels are brought in contact with the rim when the crane is lifting the load. The base is secured to the car or truck by eight bolts on the inside, leaving the outside clear of obstructions. Attached to the inside of the base is a bracket carrying a buffer spring, and on the under side of the turntable platform is cast a stop. The crane is enabled to swing through a complete circle, less 4 ins., which is taken up by the buffer.

The turntable is centered or held in position by a 5-in. pin on the 1,000-lb. cranes. The brake bracket is equipped with rollers and an air cylinder, the valve of which is controlled by a treadle convenient to the operator's foot. The boom is composed of a pair of steel channels, stiffened by truss rods and supported by a vertical post on the turntable. In the pivoted boom in Fig. 1, the boom is adjusted by means of a nut and hand-wheel riding on a threaded rod.

The hoisting cylinder is carried on the boom, and its piston rod carries a sheave. The cable is attached to the head of the boom, passes around this and then back to the sheave at the head of the boom. For a lift of 12 ft. 6 ins. a two-part cable is ordinarily used. The pipes and valves are grouped conveniently to the operator, as shown in Fig. 3. On cranes of 1,000 lbs. capacity,

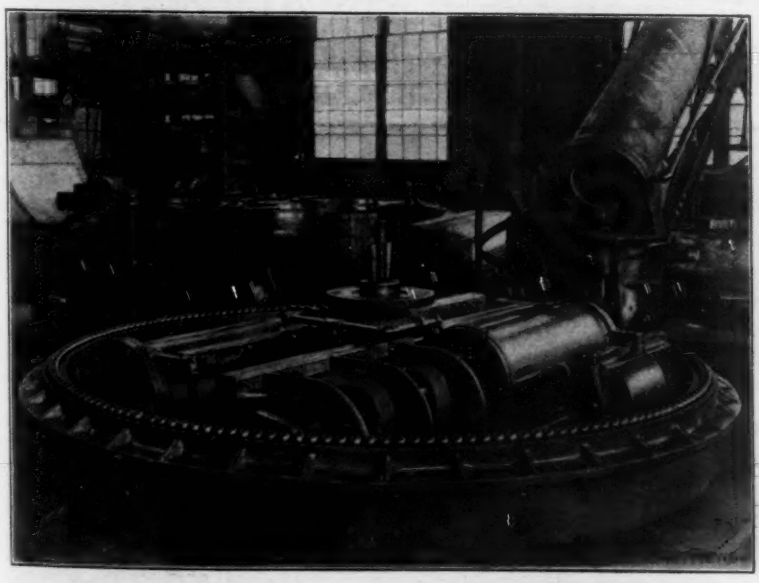


FIG. 2. BASE OF TURNTABLE OF PNEUMATIC CRANE.

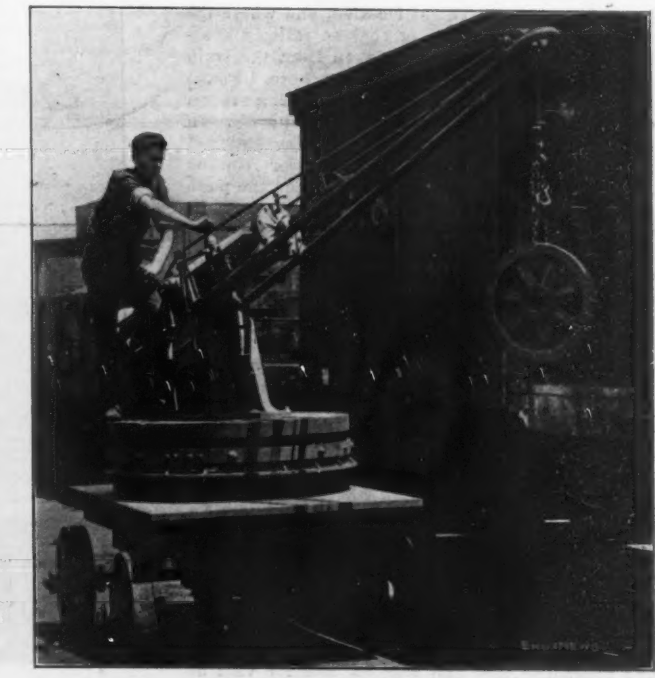


FIG. 3. PORTABLE PNEUMATIC CRANE LOADING CARS.

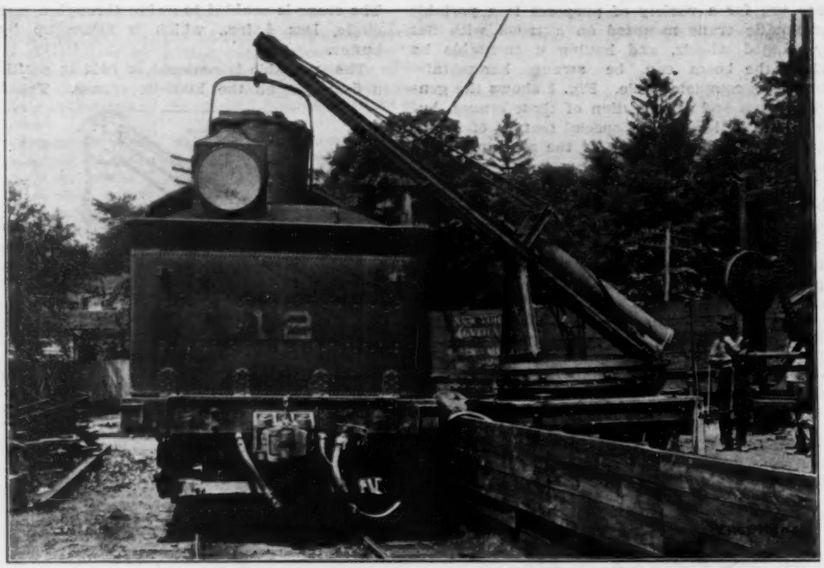


FIG. 4. COALING LOCOMOTIVES WITH PNEUMATIC REVOLVING CRANE.
Fonda, Johnstown & Gloversville Ry.

the hoisting cylinder is 8½ ins. diameter, and the racking cylinder 8 ins. Cranes of 10,000 lbs. capacity have a 21-in. hoisting cylinder and two 10-in. racking cylinders. The hoisting speed depends upon the air pressure and load, 75 ft. per minute being the maximum for short lifts. The operating valve is of special design, so arranged that the air exhausted from one end of the cylinder passes to the other end. Thus the air admitted above the piston in raising the load escapes through the valve as a bypass to the rear end of the cylinder in lowering the load, the load being controlled by regulating the flow of air through this valve. The valve is of brass, ground to a close fit in a cast-iron body, and held in position by a helical spring.

The weight of a crane of 1,000 lbs. capacity is 3,800 lbs. if mounted on a hand truck, or 4,600 lbs. if mounted on a car. The 4,000-lb. crane weighs 8,700 lbs.; and the 10,000-lb. crane, with car and counterbalance, weighs 21,300 lbs. The cranes are designed to work with an air pressure of 80 lbs. per sq. in. The air is used for hoisting the load, revolving the crane and operating the brake; in special cases it is used also for traversing the machine along a track. The air is compressed at any convenient location, and where the crane is used for handling coal at railway coaling stations, the air can be taken from the train pipe by coupling up to the tender hose. Fig. 4 shows this arrangement in use at a coaling station on the Fonda, Johnstown & Gloversville Ry. In this case the truck is stationary, being clamped to the rails; the clamps are tightened or released by the hand wheels and screws shown on the platform of the crane truck. The cranes can be equipped with storage reservoirs if necessary They are usually fitted with rail clamps to prevent tipping when raising a heavy load, but they may be provided with a counterbalance instead of the clamps.

These cranes are in use by several railways, including the New York Central Ry, Chicago, Burlington & Quincy Ry., Chicago, Rock Island & Pacific Ry., etc. They are used in storerooms or on platforms for loading, unloading and piling material. They are also used in the shops for handling wheels, axles, car timbers, ties, etc. At some junction points they are used for coaling locomotives, a series of drop-bottom buckets being filled direct from the coal car and placed in a circle on the platform within reach of the revolving pneumatic crane. Manufacturing concerns, including the Standard Oil Co., the American Car & Foundry Co. (Detroit), and Wm. Wharton, Jr., & Co. (Philadelphia), are using the cranes for loading and unloading cars and wagons, and for various other purposes. They are made with a hoisting capacity of 1,000 lbs. to 10,000 lbs.; those in most general use being of 2,000 lbs. and 4,000 lbs. capacity. The reach of the smaller machines is 7 ft., and of the larger ones 12 ft.; all have a lift of 12½ ft. The Atlas Works of the Standard Oil Co., at Buffalo, have a 10,000 lb. crane for handling large tanks.

A somewhat different form of rotary pneumatic crane is shown in Fig. 5. This has a steel tower on the turntable, and a horizontal boom with a hoisting trolley. The hoisting and lowering is operated by the larger cylinder inside the tower, while the trolley is racked in and out along the boom by the smaller cylinder at the back of the tower. The piston rod of this latter cylinder carries a vertical rack which gears with a pinion on the shaft of the rope sheave at the heel of the boom.

These portable pneumatic rotary cranes are a specialty of the Garry Iron & Steel Co., of Cleveland, O., and we are indebted to the makers for plans, photographs and other information.

THE WATER POWER OF THE DRAINAGE CANAL at Chicago is to be developed under the direction of the Sanitary District. Such action has several times been suggested, but no definite action has been taken until recently, when the Drainage Board decided to take advantage of the water power laws passed by the last Legislature. Mr. Isham Randolph, the Chief Engineer, has been instructed to prepare plans for the development of water power at Lockport and at Joliet, the total development being about 7,000 HP. It is probable that bids will be received in October, and the work will probably cost $2,700,000 and extend over two years.

AN UNDERGROUND MAIL AND PARCEL SERVICE for Chicago is provided for by the amended ordinance granted to the Illinois Telephone & Telegraph Co., whose system of tunnels has been described in our columns. The original ordinance was for the use of the tunnels for telephone service only, but under the new ordinance the company may carry newspapers and mail matter, parcels or merchandise, but passenger traffic is prohibited. The company must have 50 miles of tunnel in ten years, and facilities for 20,000 telephones in five years. It must pay to the city 5% of the gross annual receipts for the first ten years, 8% for the second ten years, and 12% for the remainder of the term. The franchise is for 26 years, at the end of which time all the tunnels and conduits are to become the property of the city.

AN ESTIMATE OF WATER POWERS developed in the several countries was given by A. Gradenwitz in a paper before the Frankfort Congress of German Naturalists and Doctors. His figures are as follows: Germany and Austria, 180,000 HP.; Switzerland, 160,000 HP.; Sweden, 200,000 HP.; United States, 400,000 HP. He estimates the total available water power to be: Sweden, 2,000,000 HP.; France, 10,000,000 HP.; Germany, Austria, Switzerland and Italy, 10,000,000 HP.; while in the United States, Niagara Falls alone could furnish 10,000,000 HP.

SCRAP-TIN, to the extent of 30,000 tons annually, is now treated by seven electrolytic plants in Germany. Only 3½% of the scrap is tin which is dissolved by sodium hydrate and precipitated by electrolytic action in the form of spongy tin.

PRECIOUS STONES to the value of thirty million dollars were imported during the fiscal year just ended. This is the largest importation of diamonds and other precious stones ever shown in a single year of our commerce. About 40% of the diamonds were uncut.

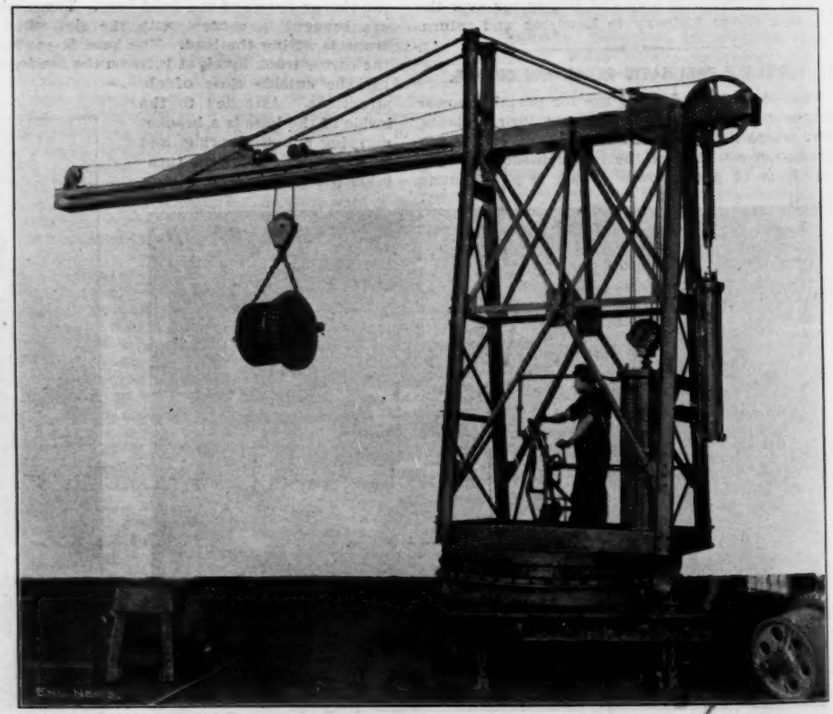


FIG. 5. PNEUMATIC REVOLVING CRANE WITH HORIZONTAL BOOM AND HOISTING TROLLEY.